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TELEMEDICINE STRATEGIC PLANNING AND IMPLEMENTATION ISSUES IN THE NAVY MEDICAL DEPARTMENT

by

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September 1995

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**TELEMEDICINE STRATEGIC PLANNING
AND IMPLEMENTATION ISSUES
IN THE NAVY MEDICAL DEPARTMENT**

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ABSTRACT

Telemedicine is a system of health care delivery which combines image, video, sounds and text, enabling health care providers to consult one another and to examine patients at a distance through the use of telecommunications technology. There are currently a number of telemedicine initiatives within the Department of Defense (DoD) designed to improve the delivery of health care within the military health services system. Telemedicine demonstration projects and consultation sites have been deployed at Army, Navy, and Air Force medical treatment facilities. These initiatives have been driven by recent advances in telecommunications technology, digital imaging technology and video teleconferencing (VTC) technology, coupled with pressures to reduce health care costs and improve access to scarce medical specialist resources. This thesis provides a contextual framework for the analysis of the potential effects of telemedicine on the Navy health care delivery system. The analysis is developed through the review of current telemedicine and telecommunications technology, examination of strategic planning and implementation issues facing Navy telemedicine efforts, and an assessment of the merits and problems associated with implementing a telemedicine pilot project in a Navy medical treatment facility.

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I. INTRODUCTION

A. BACKGROUND

In 1994, the American public spent nearly \$1 trillion on health care, almost 16 percent of its Gross Domestic Product (GDP). National health care expenditures have risen by 10.5 percent per year for the past eight years, more than double the rate of increase in the consumer price index (NIST, 1994, p.43).

The American health care industry has succeeded in developing the most advanced medical technology in the world. However, the health care industry has been far less progressive in its use of telecommunications and information technology to improve its traditional, paper-intensive patient care, diagnostic and clinical processes. The United States has not yet linked the telecommunications infrastructure to the health care infrastructure. To date, only local and regional pilots are in testing or operation. Fortunately, the United States is evolving toward a new health care infrastructure that will leverage telecommunications and information technology. The movement to incorporate information technology in health care is now being accelerated by intense private and public pressure on the health care industry to reduce costs, provide greater access, and improve quality.

A 1992 study performed by the Arthur D. Little International Consulting Organization concluded that telecommunications and information technology can reduce annual health care expenditures in America by more than \$36 billion through four applications (A.D. Little, 1992, p. 13):

- Electronic management and transport of patient information (reduction of almost \$30 billion).
- Electronic submission and processing of health care claims (reduction of almost \$6 billion).
- Electronic inventory and management systems (reduction of more than \$600 million).

- Video conferencing for professional training and remote medical consultations (reduction of more than \$200 million).

These issues are especially relevant to the Department of Defense in an era of declining resources coupled with pressures to reduce health care costs, improve access to health care and improve the quality of health care for all DoD beneficiaries. Recognizing the potential value that telecommunications technology can play in resolving these issues, the Assistant Secretary of Defense for Health Affairs, Dr. Stephen C. Joseph, established the DoD telemedicine test bed on 1 September 1994 to manage rapidly advancing digital communications technologies with military medical applications. On 7 September 1994, Dr. Joseph proposed that the Army Surgeon General serve as the DoD Executive Agent for telemedicine activities and directed the Army's Assistant Surgeon General for Research and Development to develop a management plan to guide the telemedicine test bed projects. The purpose of the telemedicine test bed is to re-engineer the delivery of military health services by promoting rapid evolution and integration of telemedicine into the Military Health Services System (MHSS) infrastructure. This is to be accomplished by using new techniques and advanced technology that exploit telecommunications (Edwards, 1994, p.1).

B. OBJECTIVES OF THE THESIS

The primary objective of this thesis is to provide a contextual framework for the analysis of the potential effects of telemedicine on the Navy health care delivery system. This framework will be developed through the review of current telemedicine and communications technology, examination of strategic planning and implementation issues facing Navy telemedicine efforts, and assessment of the merits and problems associated with implementing a telemedicine pilot project in a Navy medical treatment facility. The following strategic principles contained in the Department of Defense Telemedicine Test Bed Management Plan will be used as the foundation for this evaluation and provides the basis for the research questions proposed in this thesis:

- **Readiness Orientation.** Military telemedicine will focus on the evolving nature of military battlespace and the military medical environment to support assigned or implied operational missions
- **Patient Focus.** Telemedicine will proactively focus on developing total access for difficult-to-serve, expensive-to-serve, and under-served patients who rely on military medicine for prevention, diagnosis and treatment.
- **Rapid Prototyping and Process Re-Engineering.** The test bed will use rapid prototyping and process re-engineering for development of new medical practices and advanced technology applications.
- **Outcomes-Based Metrics.** The test bed projects must have potential for measurable, reproducible improvement of outcomes. Outcomes evaluation will combine peer review, clinical trials, economic analysis, and statistical techniques to ensure quality, access, and cost benefit.
- **Open and Integrated System Architecture.** Test bed projects will be designed to achieve interoperability, scalability, and upgradeability. Moreover, they will totally integrate with existing DoD medical systems to provide patient-and provider-friendly systems.
- **Leveraged Development.** The demands of advanced technologies mandate active outreach and collaboration with academia, industry and other governmental agencies to leverage development. Commercial and/or Government Off-the-Shelf (COTS and GOTS) Technology will be maximized.
- **Sound Business Practices.** Test bed project management will utilize a management approach that follows sound business practices.

C. RESEARCH QUESTIONS

According to the Arthur D. Little study referenced in the previous section, telecommunications technology applied to medicine has great potential for helping to overcome problems associated with medical access (especially for geographically isolated areas), for enabling patients to be seen at a lower cost per capita (especially if costs such as transportation and lost productivity are included in the analysis), and for improving quality of care through more ready access to medical information and education.

There are numerous accounts relating the life-saving or hospital-transfer-averting results of telemedicine consultations. However, few if any of these accounts have been formalized as a case-report or case-series in the medical literature. This points to a significant deficit in the understanding of the critical issue in telemedicine; the relative lack of scientific, peer-reviewed evaluation. Therefore, the most important fundamental questions, 1) What processes in the health care delivery system can telemedicine improve? 2) How can telemedicine improve the identified processes? and, 3) Is telemedicine an appropriate technology investment for improving the identified processes? have not been answered except at a preliminary level. Some telemedicine proponents feel that the current technology is driven by enthusiasm and often not controlled by proper skepticism, and the level of implementation has exceeded the level of evaluation. The danger is that telemedicine may be used inappropriately; that the wrong technology may be used for certain applications, and that expensive installations may not be cost-effective in an increasingly constricted medical economic environment (Allen, 1995, p. 4).

Using the Department of Defense Telemedicine Test Bed strategic principles as a guide, and the telemedicine pilot project at Naval Hospital Camp Pendleton (NHCP) as the research study, the following research questions are proposed:

- Does the Navy telemedicine initiative support assigned or implied operational missions?
- Does the Navy telemedicine initiative proactively focus on developing total access for difficult-to-serve, expensive-to-serve, and under-served patients who rely on military medicine for prevention, diagnosis, and treatment?
- Does the Navy telemedicine initiative provide process re-engineering for development of new medical practices and advanced technology applications?
- Does the Navy telemedicine initiative provide measurable, reproducible improvement of outcomes?
- Is the Navy telemedicine initiative designed to achieve interoperability, scalability, and upgradeability?

- Is the Navy telemedicine initiative leveraged through outreach and collaboration with academia, industry and other governmental agencies?
- Is the Navy telemedicine initiative managed to reflect sound business practices?

These questions will be addressed through the data collected from the Naval Hospital, Camp Pendleton telemedicine pilot project as well as findings provided from other Navy telemedicine project efforts described in this thesis. The answers to these questions will provide the basis for the development of a framework to evaluate the potential effects of the Navy telemedicine initiative from a strategic planning perspective.

D. SCOPE OF THE THESIS

The scope of this thesis includes a review of telemedicine history and technology, a review of state, regional and local telemedicine projects throughout the United States, a review of current telemedicine strategic issues in the Navy Medical Department, and the analysis of a telemedicine pilot project at Naval Hospital, Camp Pendleton. Appendices to this thesis provide detailed information on telemedicine organizations, telemedicine projects in progress at state, regional and local areas within the United States, and peripheral equipment used with telemedicine systems. The technology discussions contained in this thesis are general in scope and are not designed to provide the level of detail required for the implementation of a telemedicine system, but rather serve to provide a basic overview of telemedicine and telecommunications systems.

E. METHODOLOGY

The methodology used in this thesis includes a literature review, consultation with Navy telemedicine project personnel, and a case study. The literature review consists of:

- A MEDLINE literature index search of telemedicine subjects through the National Library of Medicine.
- A Hospital Literature Index search of telemedicine subjects through the National Library of Medicine.

- A Telemedicine Resource Center (TRC) database search of telemedicine subjects utilizing the Telemedicine Information Exchange (TIE).
- A Computer Select database search of telemedicine-subjects at the Naval Postgraduate School library.
- An IEEE database search of telecommunications subjects related to telemedicine at the Naval Postgraduate School library.
- Review of various studies, reports and other documentation related to telemedicine projects and issues, both within the DoD and the private sector.

The consultation efforts consist of:

- Collaboration with Naval Medical Information Management Center (NMIMC) telemedicine project officers on telemedicine plans and initiatives.
- Attendance at the NMIMC 5th Annual Management Information Systems Officers Conference.

The case study methodology consists of:

- Development of a telemedicine demonstration project system evaluation survey instrument.
- Development of a telemedicine demonstration project patient satisfaction survey instrument.
- Development of a telemedicine pilot project log to capture telemedicine consultation information.
- Collaboration with the NHCP telemedicine project director on project requirements and objectives.
- Direct observation of telemedicine providers, patients and interactive consultations.
- Evaluation of project data collected from survey instruments.

This case study is focused on specific technology and management issues in implementing a telemedicine system at an individual site. It is not the intent of this case study to draw generalizations from the conclusions obtained here and apply them to other situations. As Robert Yin states in *Case Study Research Design and Methods*:

Case study conclusions are generalizations to theoretical propositions and not to populations or universes...In this sense a case study does not represent a 'sample' and the investigator's goal is to expand and generalize theories (analytic generalization) and not to enumerate frequencies (statistical generalization). (Yin, 1988, p.21)

F. ORGANIZATION OF THE THESIS

This thesis is composed of six chapters. This chapter provides the introduction, objectives, research questions, scope and methodology employed to conduct the research. Chapter II provides a background on telemedicine history, technology, equipment standards and communications systems. Chapter III discusses telemedicine strategic issues and current telemedicine initiatives in Navy Medicine. Chapter IV describes the Naval Hospital, Camp Pendleton telemedicine pilot project. Chapter V discusses the Naval Hospital, Camp Pendleton pilot project findings. Chapter VI provides the conclusions, summary, and recommendations for future research.

II. TELEMEDICINE SYSTEMS OVERVIEW

A. TELEMEDICINE DEFINITIONS

The practice of medicine has become heavily dependent on a variety of forms and types of information. The information is often contained in images, video, sounds and text. A physician is frequently required to use multiple forms of patient data and to consult with other physicians on the most effective protocols for patient treatment (McGarty, 1992 p. 1105).

Telemedicine is a system of health care delivery which combines image, video, sounds, and text, enabling physicians to consult one another and to examine patients at a distance through the use of telecommunications technology. The term "telemedicine" is derived from the Greek "tele", meaning at a distance, and from the Latin "mederi", meaning healing (Bashshur, 1975).

Telemedicine in the strictest sense, means live, interactive audiovisual communication between physician and patient or between physician and physician. This fully interactive definition is referred to as 2:2, since each party uses two-way video and two-way audio (Preston, 1993, p.1).

The Navy defines telemedicine as an umbrella term which encompasses various technologies applicable to the delivery of health care including:

- Teleradiology - digitization, transmission, storage and display of radiographic images for consultation and primary diagnosis.
- Interactive Teleconsultation - use of video teleconferencing technologies to facilitate consultation between patient and provider, or between consulting physicians for diagnosis and health care management.
- Diagnostic Still Image - digitization, transmission, storage and display of medical images for consultation and primary diagnosis. Uses include dermatology, cardiology, urology, pathology, and orthopedics.
- Teletraining - use of video teleconferencing technologies to provide training opportunities to the medical community to include continuing medical education

seminars, conferences and required professional and technical training (NMIMC 1995).

B. A BRIEF HISTORY OF TELEMEDICINE

Although telemedicine is often considered a recent innovation, evolving as part of the telecommunications innovations of the past decade, it actually dates back to the late 1950s.

In 1959 the University of Nebraska began using two-way, closed-circuit microwave television for medical treatment and education (Roberts, 1980). The first application was a video broadcast demonstration involving neurological patients and case presentations to first-year medical students in laboratories across the campus. Other applications at the University of Nebraska followed, including a two-way, closed-circuit microwave television system between the Nebraska Psychiatric Institute and Norfolk State Hospital located 112 miles away. This system provided neurological and other telemedicine consultations to the hospital, as well as ward administration services, education and training, and research collaboration (Preston, 1993, p. 5).

Another early application of telemedicine, the Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC) program, also began in 1959. STARPAHC delivered health care to residents of the Papago Indian Reservation in Arizona. It operated as a joint project of Lockheed, the National Aeronautics and Space Administration (NASA), and the U.S. Public Health Service. Its purpose was to carry out research in the use of audio and audiovisual telecommunications to provide medical service to astronauts in space, and to provide general medical service to communities on the reservation.

In 1968, the U.S. Public Health Service funded a study which implemented an interactive teleradiology system between Massachusetts General Hospital (MGH) in Boston and the Logan International Airport medical station located 2.7 miles away. By means of a two-way audiovisual microwave circuit, physicians at MGH provided medical care to over 1000 patients using this system. Diagnoses were made over the video link by a hospital physician with the help of a medical assistant at the airport. In this study, the teleradiologists

were compared to diagnoses made on the same patients who later traveled to a physician's office; 98 percent of the video diagnoses were deemed accurate and the remaining 2 percent erred on the side of diagnostic safety (Murphy, 1974).

Dartmouth Medical College also developed a telemedicine project of large geographical scope in the late 1960's called the Interact System. It provided a variety of specialty consultations and treatment service to eight communities in Vermont and New Hampshire via microwave. The Interact System also provided a continuing education curriculum for physicians, nurses, and ancillary medical personnel (Siebert, 1975).

In these early systems, the technology, although constrained in terms of transmission-relay, audio quality, and equipment reliability, functioned well enough to demonstrate feasibility and clinical effectiveness. However, the efforts of STARPAHC, MGH, and the Interact System were not continued past the 1970's. With the exception of NASA's experimentation with telemedicine conducted for the manned space vehicle program, the 1980's represented a decade of almost no telemedicine activity (Preston, 1993, p.7).

These early systems, often referred to as "first generation" were discontinued for a number of reasons:

- Telemedicine programs were not properly managed. The provision of telemedical services was not assigned to a specific department in any of the participating medical schools, and lines of authority and responsibility were not clear. Telemedicine was considered to be a communication device or tool, not an information system to augment existing services.
- It was not clear what specific needs were to be met by each telemedicine project. Therefore, there was no way to determine the extent of their success or failure.
- Most early systems focused on a limited set of clinical functions, restricting their potential use. Health professionals of that time failed to fully exploit the system or its components. The users of telemedicine did not utilize the systems to better manage their time or improve their clinical skills.
- There was no systematic empirical research conducted to evaluate the true effects of telemedicine on the cost, quality and accessibility of care.

- There was no serious or competent analysis of the cost and benefits of telemedicine that could be used to serve as a valid basis for policy determination (Bashshur, 1994, p. 9).

As a consequence of these problems, the expectation of telemedicine in the 1970s as a solution to the problems of high cost and uneven quality of health care, health resource maldistribution, and limited accessibility to care for some people were not realized. Subsequently, federal funding required for the early "first generation" telemedicine programs was discontinued and they ceased to exist.

After a latent period of almost two decades, technological innovations in telecommunications technology in conjunction with pressures to reform the health care delivery system have presented renewed opportunities for telemedicine. A number of telemedicine organizations have recently been formed to provide consultative services, promote collaborative telemedicine efforts, coordinate telemedicine standards activities and develop public policy. A listing of telemedicine organizations and their specific interests is provided in Appendix A. These organizations are involved in a number of regional and local telemedicine projects throughout the United States. A comprehensive listing of telemedicine projects by state is provided in Appendix B. The Department of Defense is also heavily investing in telemedicine feasibility and demonstration projects, including the participation of the Naval Hospital, Camp LeJeune, in the North Carolina telemedicine network initiative.

C. TELEMEDICINE TECHNOLOGY

As illustrated in Appendix B, a wide variety of telemedicine systems currently exist throughout the United States. Telemedicine systems vary significantly in configuration depending on the specific clinical applications that are required. This section will provide an overview of telemedicine equipment, transmission modes, and standards. A listing of telemedicine equipment suppliers and products is provided in Appendix C.

1. Telemedicine Equipment Components

The equipment of a telemedicine system includes the hardware and software required to capture and display visual images, sounds, and data (Preston, 1993). There are basic components common to all 2:2 telemedicine systems: the camera, the microphone, the speaker and monitor, the multiplexer (MUX) and Channel Service Unit/Data Service Unit (CSU/DSU) converter, the Coder/Decoder module (CODEC), and the user interface or keypad. If still diagnostic images are transmitted, they can be captured directly from diagnostic imaging equipment using direct digital capture (DDC) in their original digital form as data files, or they may be scanned in as images from high-resolution scanners. Documents (such as medical records) or objects (such as pathology specimens) can be placed on a light table and imaged by a "camera-on-a-stick" video visualizer or document camera. If the telemedicine system utilizes a satellite transmission mode, additional equipment is required to provide the satellite uplink and downlink. The rapidly increasing capabilities of telemedicine equipment components to process and compress digital image data can be attributed to advances in digital electronics, information theory (a branch of mathematics devoted to representing and transmitting information), digital communications and networking, and the study of how the human eye and brain process visual information. These technological leaps have driven down the cost of videoconferencing and digital imaging equipment and made it possible to send much more information over existing communications lines, greatly lowering communications costs (Hostetler, 1994, p.126).

a. Interactive Video Equipment

Transmission bandwidth is a measure of the information-carrying capacity of a communications channel, usually defined as the difference between the limiting frequencies of a continuous frequency spectrum (for analog signals), or the number of data bits per second (for digital signals) (Stallings, 1994, p. 63).

Full motion analog video requires a large amount of information to be transmitted in a very short period of time. Therefore, a large amount of bandwidth is required for full motion video. An uncompressed analog video signal, once digitized, must

be transmitted at a rate of approximately 90 million bits per second (Mbps) to achieve real-time video; a bandwidth equal to about 4500 standard phone lines (PictureTel, 1993).

The heart of the video telemedicine equipment set which enables the transmission of this data in a real-time interactive mode is the CODEC, (an acronym for coder / decoder). The CODEC is the device that digitally codes the analog image from the camera, compresses the image with the sounds from the microphone(s), transmits the compressed digital signal to the far end while it receives the video and audio signals from the far end, decompresses the received signals, and displays them on the monitor. Before the development of CODECs, the only communications modalities capable of transmitting data of this bandwidth were satellite or microwave, both prohibitively expensive technologies for health care.

In 1982, the early generation of CODECs could compress a video signal to 1/300th of its original size while still delivering an acceptable video image. Those CODECs were the size of refrigerators, and cost a quarter of a million dollars. CODECs now cost less than one-tenth that price, are the size of a desktop computer CPU, and can produce a higher-quality video image with a signal 1/800th the original size. Most videoconferencing manufacturers' CODECs are capable of effectively "squeezing" the 90 million bits per second video and audio signal through a 128 thousand bits per second (kbps) communication channel (Hostetler, 1994, p. 127).

Video CODECS perform the following technical functions:

- Analog-to-Digital conversion of audio, full-motion video, and still graphics video signals.
- Digital video signal (full-motion and graphics) demodulation.
- Digital video signal (full-motion and graphics) coding and bandwidth reduction.
- Digital audio time delay.
- Multiplexing of the digital audio, full-motion video, still-graphics video, and data samples.

- Encryption of the multiplexed signal (Inglis, 1988).

A video signal is composed of a sequence of pictures called frames. Each frame consists of a certain number of lines, with each line containing the basic digital elements of color and brightness called pixels. In order to compress the signal, a data reduction method is required. Two techniques for data reduction are frame elimination and field (or pixel) elimination. Field elimination requires the removal of either the even or odd-numbered pixels that compose a video frame. By employing field elimination, the number of pixels is reduced by one-half. Frame elimination requires a reduction in the overall number of frames to be encoded. This process is accomplished by monitoring the changes in a frame and then eliminating any frames where little or no change occurs. Frame elimination will also update only the changes made to a frame and not the entire frame itself.

Field and frame elimination techniques are limited by the amount of motion that occurs in the video image. If a large amount of motion occurs, the picture quality may be compromised if the data compression techniques cannot compensate for the amount of change in the image. By employing frame and field elimination, however, the amount of data in a digital video signal can be reduced from 80 to 95 percent (Inglis, 1988, p. 18.8).

A tradeoff between the bandwidth and the picture quality occurs within the CODEC when video is compressed. The motion-handling capacity and picture resolution are reduced when the bandwidth is reduced. To compensate, increasingly sophisticated encoding techniques are required to maintain motion and resolution at lower bandwidths. A number of proprietary algorithms have been developed by various CODEC vendors to improve image handling at lower bandwidths.

Graphics are usually transmitted in still motion form, compressed in the same manner as full-motion video and transmitted one frame at a time by interleaving a single graphics frame within the full-motion video frames. The graphics frame is then displayed at the receiving end while the audio signal continues to be transmitted. When the

graphics image is no longer required at the receiving end, the full-motion video signal returns. This enables the image at the transmitting end to be seen and heard on the full-motion video, followed by a simultaneous graphic image and audio overlay. Following the graphics image, the full-motion video image returns (Inglis, 1988, p. 18.9)

In order to synchronize the audio signal with the video signal, the CODEC uses a time-delay procedure. Once this is performed, the audio, video, and data signals are multiplexed, encrypted, and then transmitted to the distant end (Inglis, 1988, p. 18.8).

Along with the technological advances in video signal compression and transmission, videoconferencing system costs have also dropped markedly. Customized teleconferencing sites that cost up to \$500,000 per room have been replaced by cabinet systems costing less than \$100,000 for a two-site system. In the past two years, most of the major videoconferencing companies have introduced roll-about units that cost less than \$20,000 (Hostetler, 1994, p. 126). It should be noted that in order for communication to occur, CODECs participating in the system must use the same software algorithm for coding and decoding the images and sound; either proprietary or the H.320 video standard defined by the Telecommunications Standards Sector (TSS). The H.320 standard is discussed in greater detail in the following telemedicine equipment standards section.

The next evolution in interactive videoconferencing, desktop systems, promises to bring down the price of this technology much further. PictureTel of Danvers, Massachusetts, introduced a system in 1993 that turned a personal computer into a desktop videoconferencing unit. This system was priced at \$6000 and transmitted at 56 Kbps to 128 Kbps operating at full common intermediate format (CIF), a video standard specifying a resolution of 288 lines by 352 pixels at 30 frames per second. Today, equivalent systems are available in the \$2000-3000 price range. Table 1 on the following page provides a listing of commercial desktop videoconferencing systems and a summary of their features. Other computer companies, such as Sun Microsystems and IBM are also marketing videoconferencing software for their workstations and personal computers. It should be

VENDOR/ MODEL	LIST PRICE	MAX FRAME* RESOLUTION	FRAMES/ SECOND*	H.320 STD SUPPORT?
AT&T Vistium Personal Video 1200	\$2500	352 X 288	15-30	YES
AT&T Vistium Personal Video 1300	\$4995	352 X 288	15-30	YES
Creative Labs ShareVision PC3000	\$1600	160 X 112	N/A	NO
Datapoint Minx NVS 100	\$3094	320 x 240	15-18	YES
Intel ProShare Video System 200	\$1000- \$2500	320 x 240	15	NO
InVision 3.1	\$1543	320 x 240	12	NO
Northern Telecom VisitVideo 2.0	\$2999	320 x 240	12-15	NO
PictureTel Live PCS50	\$2795	352x288	15	YES
PictureTel Live PCS 100	\$4995	352 x 288	15	YES
Target Technologies C-Phone	\$1995	720 x 484	12-15	YES
Viewpoint Systems Personal Viewpoint	\$1995	256 x 200	30	NO
Vivo 320	\$1995	352 x 288	15	YES

Table 1. Desktop Videoconferencing Systems Summary of Features. From Labriola, 1995, p. 244.

* Frame resolution, frame rate, and H.320 standard are discussed in section C.2. of this chapter.

noted that these systems still operate at speeds below the minimum allowable video transmission threshold rate required for telemedicine applications (Preston, 1993). However, new software-based compression methods, known as wavelet compression, are in development that provide data compression ratios of up to 500 to 1 (Allen, 1995, p.23). These new compression algorithms will enable live, interactive video over phone lines, bringing telemedicine capabilities to inexpensive desk-top videoconferencing units in the near future.

b. Camera

Each telemedicine site requires a video camera to transmit live images. The camera must comply with the Telecommunications Standards Sector (TSS) recommendations specifying that a video signal of 625 lines per frame and 50 fields per second be available. Each frame contains two fields and therefore results in a frame repetition rate of 25 Hertz (Churchwell, 1994, p.8). A camera with CODEC control of the remote site's camera is highly desirable for clinical applications, especially if the transmission is solely between a physician at one end and a patient at the other. Pan, tilt, and zoom capabilities are needed to enhance the video consultation and to enable the examination of the patient.

c. Microphone

Along with a camera, each site requires a microphone to detect speech and other audible information. A standard two-directional microphone connected to the CODEC is adequate. In clinical settings where confidentiality is required, a combination microphone/speaker headset engineered for distance transmission can ensure a private conversation between physician and patient.

d. Speaker and Monitor

Each field site and the central site require a speaker and color video monitor. For clinical applications requiring a large number of still image transmissions, a monitor for the live consultation and an additional monitor for the still image presentation may be necessary. The monitor must also comply with the same TSS recommendations

required for the video camera. Monitors should also have a vertical resolution of at least 400 lines, and the screen size used must be maximized in relation to the viewing distance in order to provide proper viewing (Churchwell, 1994, p.8).

e. Multiplexer and CSU/DSU Converter

The multiplexer allows two or more signals to be sent over the same path. The multiplexer performs this function by breaking up the coded message into packets or frames depending on whether Time Division Multiplexing (TDM) or Pulse Code Multiplexing (PCM) is used, and then relays digital signals to the network adapter and out to the distant end. The multiplexer also allows the user to select a fraction of the available bandwidth when combined with digital switching from the telephone companies. The ability to select the transmission speed allows some control over the expense of the transmission. The CSU/DSU (Channel Services Unit/Data Services Unit) converter is a required device if the telemedicine system utilizes a T1 network service. The CSU/DSU also provides standards and allows for testing and troubleshooting when a technical difficulty arises. Some vendors combine the multiplexer and CSU/DSU into a single unit.

f. Satellite Transmission Equipment

A satellite transmission requires an uplink to the satellite from the sending location as well as a downlink to the receiving location. The number of transponders leased on the satellite depends on whether a system will need multiple 2:2 capability; that is, teleconferences in which users at several different sites can see and hear each other simultaneously. If a KU-Band satellite link is required, a KU-Band satellite dish is required for transmission. If a C-band satellite link is required, a C-Band satellite dish is required (Preston, 1994, p. 24).

g. Electronic Graphics Tablet

The graphics tablet serves as the user interface unit and allows the user to control the camera, sound, and various computer functions of the telemedicine equipment.

h. General Peripheral Equipment

Additional equipment frequently used to augment a basic telemedicine system include a laser printer, a facsimile machine, a document camera, and a videocassette recorder. A laser printer allows a user to print pertinent parts of a patient's medical record, if needed, during a consultation. A facsimile machine is necessary if paper documents, including prescriptions requiring a signature, are sent to a remote location. A document camera is used for rapidly transmitting paper documents, but can also be directed to an x-ray on a view box for radiology review, although the pan/tilt/zoom camera works equally well for viewing. A videocassette recorder enables a telemedicine consultation to be recorded, for documentation or teaching purposes.

i. Medical Peripheral Input Equipment

Some CODECs provide standard video jacks that allow for three or four additional camera connections. Depending on the clinical application and the site's requirements, a variety of medical instruments can be added to augment the consultation. For example, a gastroscope, the fiber-optic device that allows the visualization of the stomach lining, normally transmits an image from inside the stomach to an office monitor. Connecting the gastroscope monitor to the CODEC allows the routing of the image to the remote site for viewing by a consulting gastroenterologist. A generic telemedicine configuration is illustrated in Figure 1 on the following page. A listing of common telemedicine peripheral input devices and their associated costs is provided in Appendix D.

2. Telemedicine Equipment Standards

Standards are essential to ensure interoperability between various vendors' telemedicine equipment components. Telemedicine advocates often point to the example of the facsimile machine when discussing the importance of standardization. The proliferation of facsimile machines in the past decade is a direct result of standardization. Prior to standardization, there was no interoperability; for communication to occur, facsimile machines at both ends of the transmission were required to be manufactured by the same vendor. Similarly, the first generation of commercial telemedicine video equipment was based upon proprietary CODEC algorithms, and there was no interoperability.

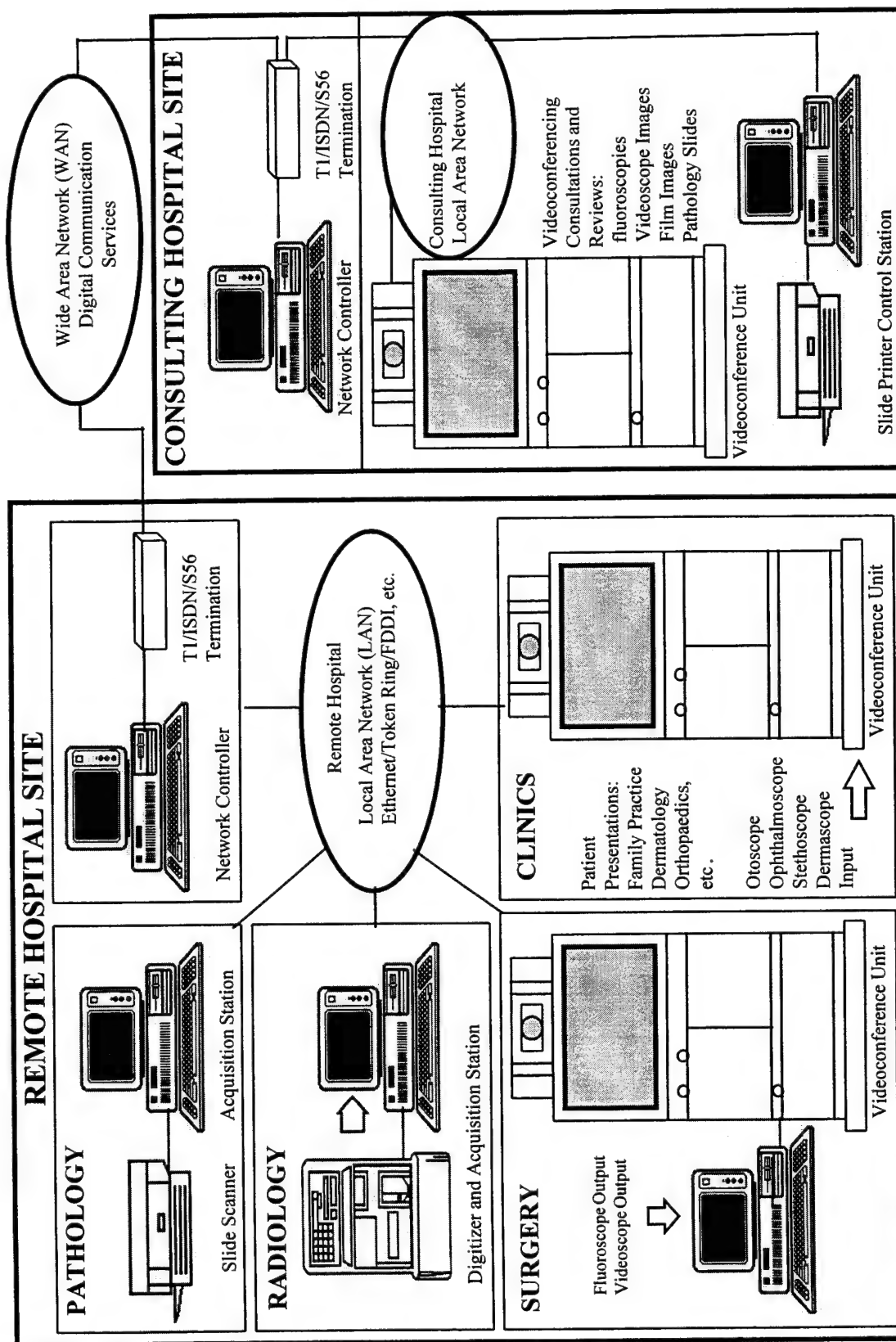


Figure 1. Telemedicine Configuration Showing Medical Peripheral Devices

Therefore, a PictureTel telemedicine system could communicate only with equipment from PictureTel.

Today, progress is occurring in telemedicine standardization. Several groups of related standards are becoming part of the telemedicine infrastructure, enabling a wider proliferation of the technology.

The Telecommunications Standards Sector (TSS), formerly known as the Consultative Committee on International Telephone and Telegraph (CCITT) has ratified the following videoconferencing standards (Freeman, 1993, p. 19):

- H.320 is an umbrella standard covering narrowband visual telephone systems and terminal equipment, including videoconferencing, audio, video, graphics, multipoint and encryption. The standard covers the entire spectrum of videoconferencing from 64 kbps to 1.92 Mbps.
- H.261 covers audio-visual services coding and decoding. It is based on an ISDN transmission medium where $H.261 = p \times 64$ kbps per second and $p = 1, 2, \dots, 30$. For $p = 1$ to 6 (56 to 384 kbps), only point to point conferencing can be used. If p is greater than or equal to 6 (384 kbps or greater), then multipoint videoconferencing is available, but more bandwidth is required. The H.261 coding algorithm uses both intraframe and interframe coding schemes. It is a hybrid of the Discrete Cosine Transform (DCT) and the Differential Pulse Code Modulation (DPCM) schemes with motion estimation.
- H.230 covers control and indication for frame synchronization.
- H.221 controls frame structure.
- H.242 establishes communications between audiovisual terminals.
- G.725 is an umbrella audio standard that covers narrow bandwidth audio.
- G.722 covers 75 KHz wideband hi-fidelity audio.
- G.711 covers conversion of 3 KHz audio into 64 Kbps streams.
- G703 and G704 cover transmission signal channel coding.

Standards established by the International Organization for Standardization include:

- MPEG1, which covers digital encoding of multimedia systems to provide VCR picture quality, similar to H.261.
- MPEG2 is an extension of the MPEG1 algorithm that will provide picture quality equivalent to interlaced broadcast television.

A number of standards affecting telemedicine have yet to be finalized by national and international bodies. Two are listed below:

- The Joint Photographic Experts Group standard, or JPEG, is a joint effort of TSS and ISO. The group is developing a standard for general purpose, continuous-tone gray scale or color still-image compression known as digital compression and coding of continuous-tone still images.
- The HDTV, or high-definition television standard, awaits approval by the Federal Communications Commission. This standard will determine how digital multimedia images will be broadcast.

These standards are designed to address three critical factors essential to the performance of telemedicine video equipment:

- Frame rate, or how frequently a new video image is displayed on the screen, measured in frames per second.
- Resolution, which includes clarity of color, contrast, and image depth.
- Motion, or how evenly and smoothly the image moves on the screen.

Although the establishment of standards is designed to provide interoperability and put an end to the "stovepipe" issue, a major problem still lingers; the CODEC algorithms vendors spent years developing and perfecting were proprietary, and were created to operate on telemedicine systems developed *before* the H.320 standard was implemented (Freeman, 1993, p. 16).

To comply with the TSS standards, telemedicine equipment vendors sacrificed audio and video quality. Doctors often found that images produced by telemedicine equipment that complied with the standards were of such poor quality that they could not be used for diagnoses. Standardization therefore produced systems that talked to each other, but communicated nothing that was useful.

Because compliance with TSS standards resulted in a negative impact on quality, many vendors initially chose to disregard the TSS standards. More recently, vendors have developed ways to satisfy the needs of both picture quality and interoperability with a "work around" solution. Vendors are manufacturing CODECs that contain both the proprietary algorithm and the H.320-compliant algorithm. The user can flick a switch and change from one to the other, depending on which one works best. Therefore, many telemedicine proponents believe that the lowest common denominator, the TSS standard H.320, needs to be of higher quality before the resolution between various vendors' telemedicine systems will be adequate (Freeman, 1993, p. 16).

3. Telemedicine Communications Systems

As discussed previously in section 1 of this chapter, a video signal is composed of a sequence of pictures called frames. The video standard defined by the National Television Standards Committee defines a frame refresh rate of 30 frames per second. The combination of these refresh rates with approximately 250,000 pixels per frame yields the picture quality found in broadcast quality television. If each pixel is composed of 12 bits, this represents a data rate of 90 million bits per second. This data rate would require the equivalent of 1200 high speed or 4500 standard telephone lines (PictureTel, 1993).

Digital representation of radiological images requires monitors to have 2000 by 2000 pixels of 12 bits per pixel or better. This represents 48 million bits per image. The response time for a screen to be transmitted should be less than 0.5 seconds, which corresponds to a data rate of 96 million bits per second (McGarty, 1992, p. 1105).

Both video and still diagnostic images are, therefore, extremely bandwidth-intensive. In the current technology environment, data rates of 90 million bits per second are

impractical. The TSS data compression standards and data compression algorithms provided by the CODECs enable this information to "squeezed" into the bandwidth provided by existing media. Current practical data rates, frame rates, and image resolution levels for telemedicine systems are provided below:

For full-motion interactive consultation:

- 384 Kbps; the slowest speed at which physicians can reliably detect a fine tremor or pupillary reflex (Preston, 1993).
- 12-15 frames per second (algorithm dependent).
- 352X288 pixel resolution for live video (H.261 Common Intermediate Format).
- 704X576 pixel resolution for still image graphics (H.261 Common Intermediate Format).

For digital representation of radiological images:

- 2048 X 2048 pixel resolution; 12 bits per pixel, with compression ratios of 2:1 to 10:1 algorithm dependent (Tillery, 1994, p.40).

Table 2 on the following page depicts some of the general characteristics of available communications media.

Once digitized and compressed, the information may be transmitted relatively long distances without theoretical loss of resolution. The particular telemedicine application and how it is to be used will drive the choice of communications system. The primary transmission media are land-based wire (or "copper" networks used by the phone system and computer networks), fiberoptic cable, microwave links, or satellite uplinks.

The type of media used will greatly influence the throughput of the entire system. Some systems, such as the Mayo Clinic Telenet, are designed as a hybrid network using several types of communications media simultaneously: satellite uplinks are used between facilities, fiber is used within facilities for video signals, and copper-based networks are used for data, signalling and control (Berek and Canna, 1994, p.23).

The Navy's telemedicine pilot project at Naval Hospital Camp Pendleton uses a hybrid network consisting of microwave, fiber, and copper (T1) to transmit telemedicine video consultations between the main hospital and a branch medical clinic located 17 miles away.

Technology	Capital Costs	Operating Costs	Bandwidth	Distance Sensitive	Applications
Telephone (analog)	Low	Low	Low	Yes	Point-to-Point, Voice/Low-Speed Data
Telephone (Digital)	Low	Low-Moderate	Moderate	No	Point-to-Point, Voice/Video/Data
Microwave	Moderate	Low	Low-Moderate	Yes	Point-to-Point, Voice/Video/Data
Satellite	High	Moderate-High	No	No	Point-to-Multipoint, Voice/Video/Data
Coaxial Cable	Low-Moderate	Low	Moderate-High	Yes	Local Multipoint, Voice/Video/Data
Fiberoptic Cable	High	Moderate	High	Yes	Point-to-Point, High-Quality Voice/Video/Data

Table 2. Characteristics of Communications Media Types From Berek and Canna, 1994, p. 23.

For each media type, there are a number of additional decisions to be made, including cost, speed, bandwidth, and the connection mode. Table 3 on the following page provides a summary of the characteristics of communications transmission modalities.

Some clinical transactions may require large amounts of data to be transmitted in an interactive, "real-time" mode. Some transactions can be accomplished by moving blocks of data prior to the consult in a "store and forward" mode, and some applications require relatively little data to be transmitted in a continuous fashion. In attempting to meet clinical demands, telemedicine planners should consider the "worst case" transmission speed and bandwidth requirements.

The time required to receive an image will generally dictate the level of interaction that is possible during the consultation. The exchange limit refers to the maximum delay time that it reasonable for a practitioner to wait for a simple image or image set (this threshold will vary from ten to 100 seconds in most situations). Images that require

more than the exchange limit time should be sent ahead of time in a "store and forward" mode. Interaction limit refers to the maximum time practical for an interactive consult using an image or study. If images can be transmitted within ten seconds, two practitioners can conduct a useful interactive consultation (Berek and Canna, 1994, p. 26).

Service	Name	Description	Speed	Connection
POTS (UTP)	Plain Old Telephone System	Analog connections through modem	300-9600 baud 14.4 kbps 28.8 kbps	Dial-up, Time-charged
Switched-56 (SW-56)	Packet Switched Data Lines, Leased Lines or Dial-Up	Switched digital service - can be multiplexed	56 kbps (up to 1.544 Mbps by multiplexing)	Dedicated local loop, time-charged for long distance
ISDN	Integrated Services Data Network	Switched digital service - can be multiplexed	2 Channels @ 64 kbps each (up to T1 when multiplexed)	Dial-up service Time-charged
T1 (DS1)	Digital Service, Time-Division Multiplexed	Copper, fiber, or microwave high-speed channels	1.544 Mbps	Dedicated Monthly-charged
T3 (DS3)	Digital Service, Time Division Multiplexed	Copper, fiber, or microwave high-speed channels	45 Mbps	Dedicated monthly-charged
10Base T	Ethernet - 10 Mbps Baseband Twisted Copper Pairs (UTP)	Common computer network protocol	10 Mbps	User Installed
FDDI	Fiber Distributed Data Interface	Fiberoptic data transfer protocol	100 Mbps	User Installed
Ku/C Band (SAT)	Satellite	Analog or digital	45 Mbps (per digital channel)	Costly uplink; earth stations billed hourly
ATM	Asynchronous Transfer Mode	Fiberoptic protocol optimized for video/voice/data applications	155-622 Mbps	In beta testing as a metropolitan Wide Area Network (WAN)

Table 3. Communications Transmission Modalities From Berek and Canna, 1994, p. 23.

Ideally, a telecommunications infrastructure should continuously adapt to the clinical requirements by providing the appropriate data transmission speeds at the appropriate times, referred to as "bandwidth on demand". The most promising technology

for this purpose is asynchronous transfer mode (ATM), a high-speed multiplexing and switching technology that is able to dynamically adjust bandwidth allocations to user requirements. ATM is currently being tested in a number of state and regional projects (see Appendix B) and should become more widely available over the next several years. Until then, the conventional strategy is to match clinical requirements with available technologies.

Figure 2 on the following page illustrates the time in seconds required to move uncompressed data across various transmission media types.

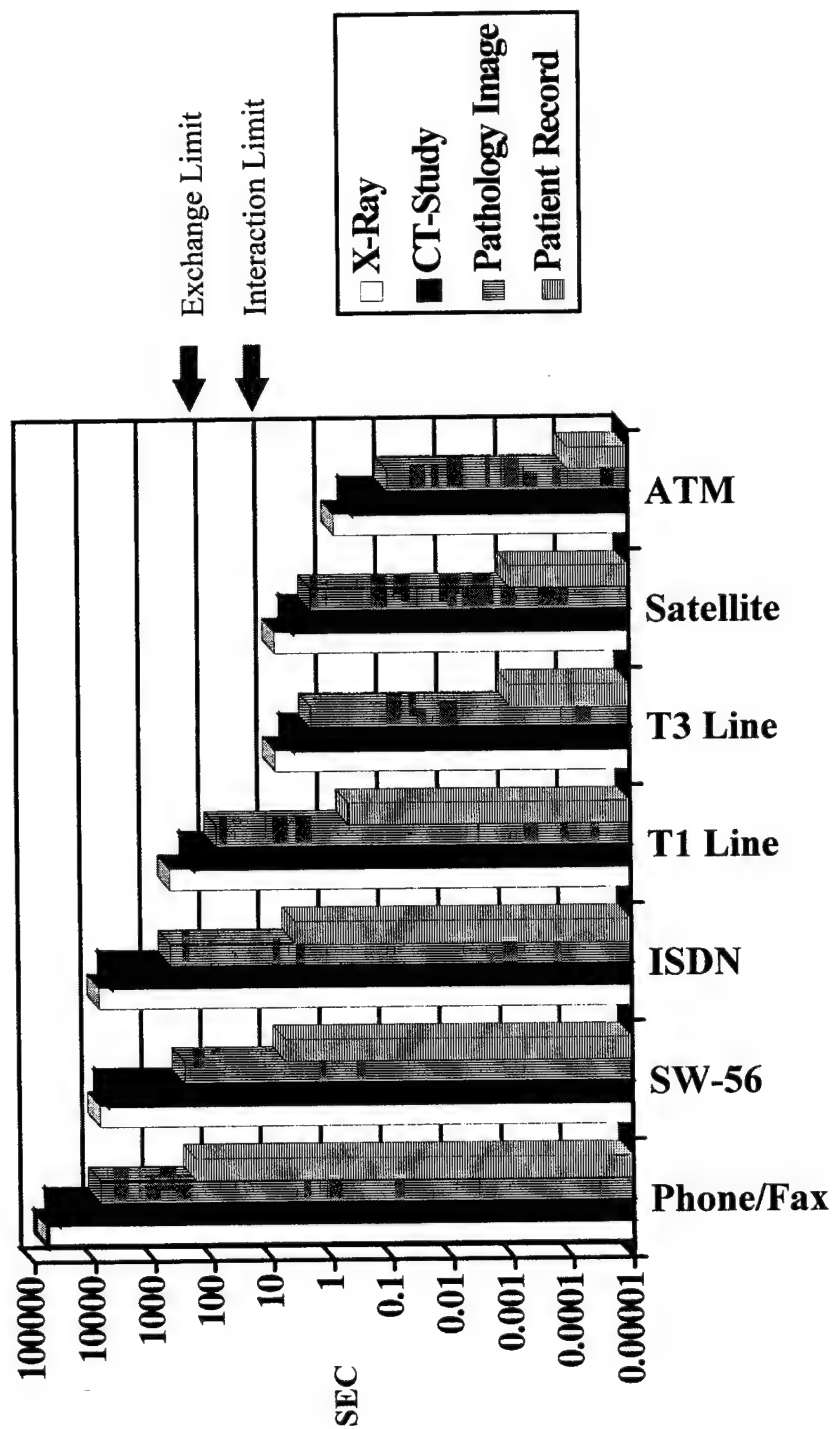


Figure 2. Transmission Media Comparison (Uncompressed Data) From Berek and Canna, 1994, p. 26

III. STRATEGIC ISSUES IN NAVY TELEMEDICINE

The Department of Defense telemedicine test bed is designed to re-engineer the delivery of military health services. The purpose of telemedicine is to support patients who rely on military medicine now and into the next century using new techniques and advanced technology that exploit telecommunications (Edwards, 1994).

One of the most critical policy concerns regarding the development of telemedicine is whether or not the dependence on telecommunications and computer technology for the delivery of health care will increase or decrease its overall cost. The emphasis on cost is necessary because the introduction of a new technology is usually accompanied by questions about its potential impact cost, and usually the potential to increase cost. Historically, the use of new medical technology has increased the cost of health care. However, while cost is important, it must be viewed in conjunction with the simultaneous impact of telemedicine on the accessibility and quality of medical care (Bashshur, 1994). Essentially, the basic strategic issue is whether telemedicine is an appropriate investment and an appropriate technology for re-engineering the delivery of health services within the Navy health care system.

The previous chapter included a discussion on the history and outcomes of early "first generation" telemedicine systems. This chapter will examine current strategic issues facing telemedicine and the strategy proposed to change the delivery of health services by the Navy Medical Department through the utilization of telemedicine technology.

Language contained in the National Defense Authorization for Fiscal Year 1995 stated:

The Navy has perhaps the most to gain from Telemedicine. It also has the most challenging technical problem since all data used must be transmitted and received using data links that are already used to capacity on most ships.

The Navy-Marine Corps team is the Nation's first strike force, called upon to carry out national policy in contingency areas around the world. United States Naval vessels are

forward deployed every day, regardless of national security posture. The operating environment of the sea services requires the capacity to function independently, with little or no real-time access to shore-based medical resources. Similarly, Navy medical treatment facilities located outside the continental United States, as well as Navy medical treatment facilities located in remote areas of the continental United States also have limited real-time access to medical resources available in the Navy's tertiary care and teaching facilities.

A. NAVY TELEMEDICINE GOALS

The stated strategic goals of Navy Telemedicine are:

- Maximize war-fighting capabilities of deployed forces through the delivery of health care.
- Deliver the best available health care independent of location.
- Optimize the use of available human and technology health care assets through the use of remote data sharing, diagnosis, and consultation.
- Design new ships with integrated telemedicine systems (NMIMC 1994).

B. POTENTIAL BENEFITS OF TELEMEDICINE FOR THE NAVY

Telemedicine has the potential to change the practice of medicine at sea and provide a number of process re-engineering benefits for the Navy health care system including:

- Increased support to the independent duty corpsman and general medical officer (GMO) at sea.
- Increased support to the independent duty corpsman and GMO in remote CONUS medical treatment facilities.
- Increased support to fleet hospitals and OCONUS medical treatment facilities.
- Reduction in the frequency of medical evacuations (MEDEVACS) from remote locations and deployed units.

- Reduction of contract radiology costs and services in remote treatment facilities.
- "Road Salary" savings through the reduction in required medical specialists' travel.
- Decreased transportation costs to patients.
- Patient empowerment through access to online and interactive telemedicine services.
- Increased continuing medical education support to remote treatment facilities.

In essence, telemedicine is a potential medical "force multiplier" which can extend medical resources into previously inaccessible areas. A number of consultative and remote telemedicine sites, described in the following section, have been established to demonstrate initial operating capabilities and to assess the extent to which telemedicine technology can change the delivery of health care services aboard ship and in remote medical facilities overseas.

C. TELEMEDICINE CONSULTATION SITES

1. National Naval Medical Center, Bethesda, Maryland

The National Naval Medical Center currently provides interactive telemedicine consultations in radiology, orthopedics, and cardiology. A ship to shore connectivity via commercial satellite provided by the Challenge Athena (OPNAV N-6) initiative has also successfully demonstrated the transmission of radiology images from the USS George Washington (CVN-73) to the National Naval Medical Center.

2. Naval Medical Center, San Diego

The Naval Medical Center, San Diego provides consultative telemedicine support to Fleet Hospital Six located in Zagreb, Croatia. Commercial telephone, military satellite, and commercial satellite transmission links have been successfully used to support video consultations as well as medical image transfer between the two facilities.

3. Telemedicine Remote Sites

a. USS George Washington

During a six month deployment in 1994 to the Mediterranean Sea, Adriatic Sea, Red Sea and the Arabian Gulf, a telemedicine system installed on the USS George Washington (CVN-73) as part of project Challenge Athena II, was used to transmit digital images from the ship to the National Naval Medical Center in Bethesda, Maryland. A total of 260 images were transmitted, including radiographs and electrocardiograms. According the Challenge Athena after action report, the telemedicine system prevented 31 medical evacuations (MEDEVACS) from the ship. The potential cost per MEDEVAC was estimated to range from \$1500 to \$4000. The telemedicine system was also stated to give the ship's medical department the "sense" of not being isolated from the rest of the medical community, provided increased access to specialists' opinions, enabled the ship's medical department to provide extended medical care and to obtain answers to questionable radiographs and difficult clinical cases in a timely manner. (Baxter, 1994).

b. Fleet Hospital, Zagreb, Croatia

The U.S. Navy's Fleet Hospital Six in Zagreb, Croatia currently transmits an average of 200 digital radiography images per week to the Naval Medical Center in San Diego, California. The system has prevented three MEDEVACS of U.S. Navy personnel, and has also provided a number of primary diagnoses of United Nations and Croatian national personnel. Through a cooperative effort with the U.S. Army telemedicine project, a bone grafting procedure was performed in the Zagreb theater with telemedicine assistance (NMIMC, 1994).

c. U.S. Naval Hospital, Guantanamo Bay, Cuba

A telemedicine system installed at the U.S. Naval Hospital, Guantanamo Bay, Cuba, is used to support the treatment of Haitian refugees contained at the U.S. Naval Base. This illustrates the application of a telemedicine system to augment the existing medical infrastructure during a large unanticipated increase in patient population.

D. THE NAVY TELEMEDICINE IMPLEMENTATION STRATEGY

The implementation strategy for Navy telemedicine includes integration of telemedicine activities into the Military Health Services System (MHSS) communications infrastructure for CONUS fixed facilities, selected medical facilities afloat, as well as remote OCONUS facilities. Figure 3 below illustrates the communications integration concept for Navy telemedicine through DISN, and the Navy Network (NAVNET):

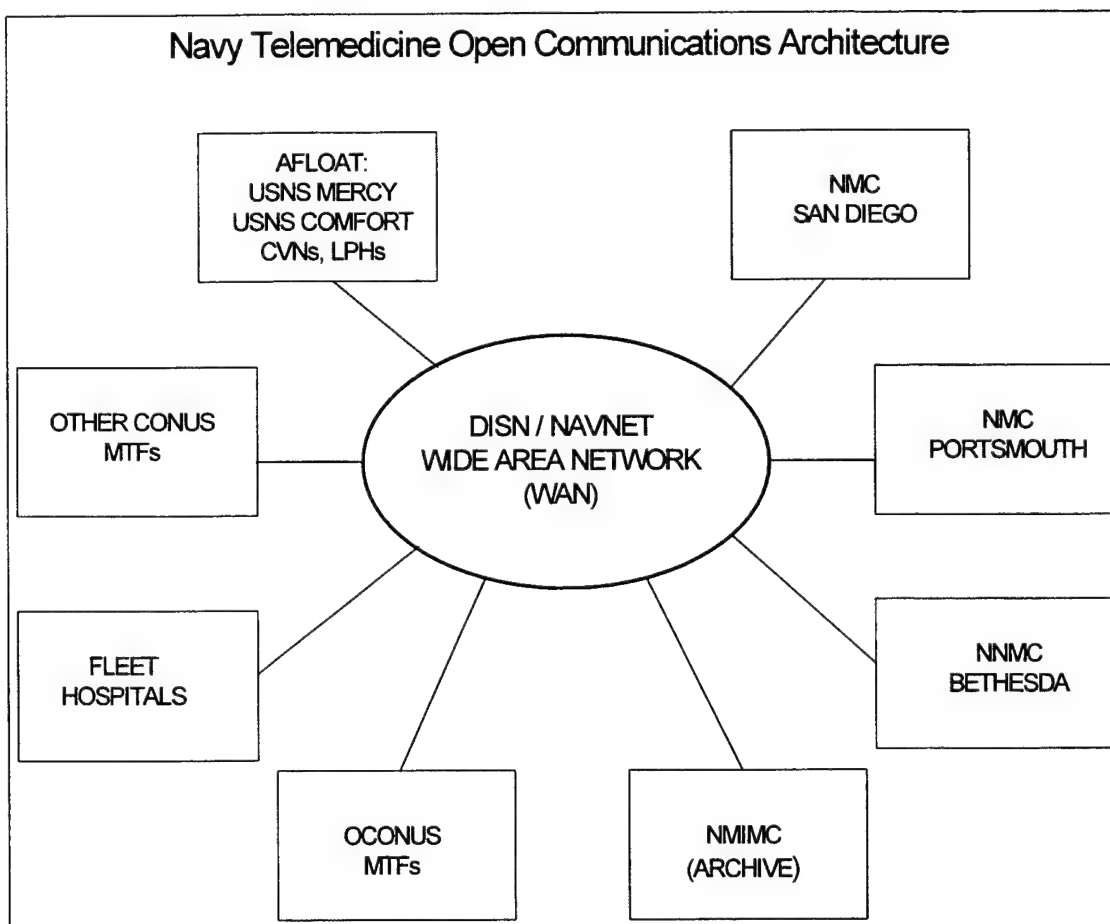


Figure 3. Top Level View of Navy Telemedicine Communications Integration Strategy
From NMIMC, 1995.

Currently, local data communications systems installed within Navy CONUS facilities consist of Ethernet 10BaseT local area networks (LANs) utilizing AT&T Model 3B2 file

servers. The LANs connect with the Defense Information Switched Network (DISN) for internetworking on a world-wide basis.

During 1995 and 1996 the Navy is planning a transition to fast Ethernet, Fiber Distributed Data Interface (FDDI) and Asynchronous Transfer Mode (ATM) networks utilizing Windows NT/AS to provide shared network resources in server-based operations. This migration strategy will be critical to the future development of telemedicine in order to provide the additional bandwidth required for interactive video teleconferencing and high volume inter-facility medical image transmissions.

For Navy Fleet Hospitals and remote facilities, alternate communication paths are envisioned for medical diagnostic imaging, including both satellite and high speed land lines. Figure 4 on the following page illustrates the alternative communications strategies.

This chapter presented the strategic issues , goals, and objectives of the Navy telemedicine initiative, and described the basic communications framework that is intended to support the future telemedicine infrastructure. The following chapter will focus on the implementation of a telemedicine pilot project at the Naval Hospital, Camp Pendleton.

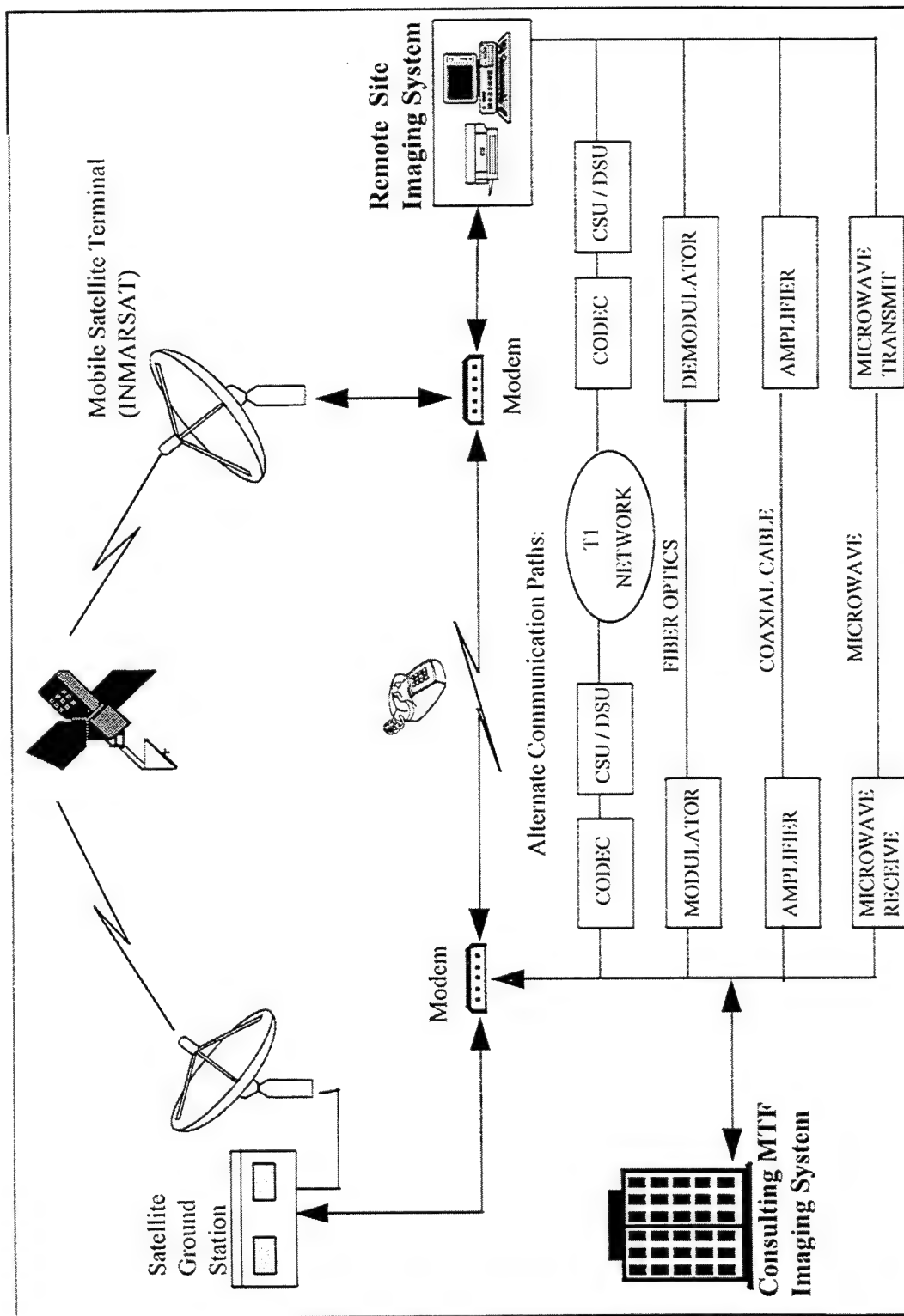


Figure 4. Telemedicine Communication Alternatives for Remote Navy Sites

IV. TELEMEDICINE PILOT PROJECT, NAVAL HOSPITAL, CAMP PENDLETON

A. PROJECT OVERVIEW

The United States Marine Corps Base, Camp Pendleton, is located on the coast of southern California, approximately 45 miles north of San Diego. Camp Pendleton, along with the Marine Corps Air Ground Combat Center in Twentynine Palms, California, comprise the Marine Corp's two major combat training facilities on the west coast.

Camp Pendleton incorporates approximately 200 square miles of training area and support facilities. The Naval Hospital, Camp Pendleton, is a 120 bed inpatient medical treatment facility supporting ten remote outpatient clinics illustrated in Figure 5 on the following page. Four of the outpatient treatment facilities, known as Area Branch Clinics 13, 21, 31, and 52, are operated by the Navy (The "Blue" side) and serve active duty service members, as well as dependents, and other eligible DoD health care beneficiaries. The remaining six outpatient treatment facilities, known as Area Branch Clinics 22, 33, 41, 43, 53, and 62 are operated by the Marine Corps (The "Green" side) in direct support of Marine units. The Naval Hospital and base medical clinics serve a total patient population of approximately 35,000 Marines in training and 29,000 dependents residing on base, as well as approximately 200,000 beneficiaries within a 50-mile radius beyond the base (NHCP, 1995).

The geographical dispersion of the clinics over a 200 square mile area, the combat training topography of the base with minimally-developed land transportation routes, and the frequency of training-related injuries and illnesses pose a challenge for patient transportation and access to hospital specialists. This environment is ideally suited for a military telemedicine test bed site, and also reflects many of the same challenges facing the delivery of health care services to rural areas in the civilian sector.

The Area 52 Branch Clinic is located approximately 20 miles from the Naval Hospital and supports the Marine Corps School of Infantry (SOI). The annual SOI student load is approximately 27,600, and the Area 52 Branch Clinic records approximately 55,000

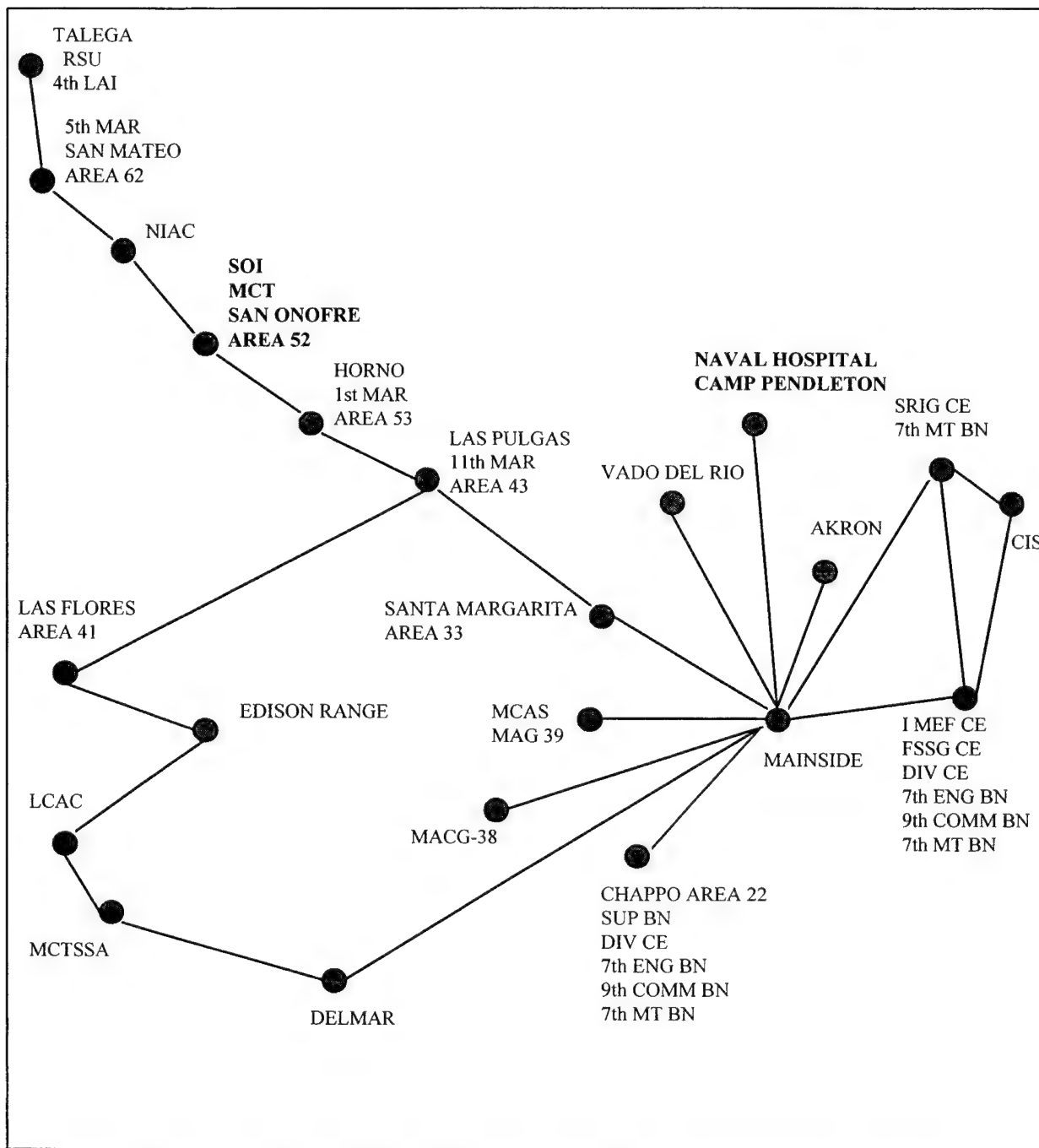


Figure 5. Map of Camp Pendleton Marine Corps Base Communication Routes.

outpatient visits annually. The clinic refers approximately 20,000 of these visits to the Naval Hospital's specialty care outpatient clinics. The average round-trip travel time between the SOI and the Naval Hospital is two hours, due to minimal speed limits over rural roads by military bus. For each Marine infantry school patient referral, the time required for transportation from the Area 52 Branch Clinic to the Naval Hospital, the clinic visit, and return transportation to the infantry training school by military bus results in the loss of a significant portion of the training day. The traditional solution to improve access to specialty care and reduce lost training hours for students is to transport medical specialists from the hospital to the outlying clinic once per week. Although this solution achieves an improvement in access to specialty care, physician productivity is lost to travel time, referred to as "road salary", and efficiency is compromised through lack of support equipment and personnel normally available in the specialty clinics.

This telemedicine pilot project is designed to address these problems through the installation of an interactive 2:2 video consultation system between the Area 52 Branch Clinic and the Naval Hospital's Sport's Medicine Clinic. The primary objective of the pilot project is to assess the effectiveness of telemedicine technology as an adjunct to the current process of patient diagnosis and management at the Area 52 branch clinic. As part of the analysis, data collection instruments were developed to assess patient and health care provider satisfaction with the telemedicine system. Data captured in this analysis was also used to estimate the reduction in the number of hospital referrals and the reduction of lost training hours for Marine infantry school patients attributed to the telemedicine system. An additional objective of this pilot project is to utilize telemedicine technology to provide education and training for medical support staff at the Area 52 branch clinic. The Naval Hospital's Education and Training Department developed a schedule of video training programs for presentation to Area 52 Branch clinic staff on a variety of enlisted advancement and continuing medical education topics. Assessment of training capabilities will also be presented as part of this case study.

B. PROJECT EQUIPMENT

The equipment for this demonstration project was provided to the Naval Medical Information Management Center by the PictureTel Corporation of Danvers, Massachusetts, as part of a Hardware Testing and Evaluation Agreement.

1. Video Teleconferencing (VTC) Hardware

a. PictureTel 4000 System

(1) System Components.

The PictureTel Model 4000EX System is a roll-about videoteleconferencing unit which includes a full color camera with pan-tilt-zoom, a 27 inch monitor, and a full function graphics tablet keypad to control the system components. The 4000EX system provides "windowing," often referred to as "a picture within a picture," to allow viewing of the "near end" (transmitter) image and the "far end" (receiver) image simultaneously. A Canon Videovisualizer Model RE-650 document camera was supplied with the system to display photographs and radiographs. The system supports NTSC and PAL video formats, freeze frame graphics, and DES encryption. The system supports data rates from 56 kbps to 768 kbps, dual V.35, RS-449 and dual X.21B and V.25 network interfaces. The telemedicine system for this project was not interfaced to a network, since this project was designed for point-to-point transmission from the Naval Hospital to the Area 52 branch clinic. A standard VHS videocassette recorder was added to the system by the hospital to enable recording of the telemedicine consultations.

(2) Data Compression Algorithms.

The system provides the PictureTel proprietary SG3, PT724 data compression algorithm (256 lines across by 240 lines down), as well as the standard H.320 (px64), H.261, G.722, G.711, and G.728 algorithms.

2. Electronic Medical Instruments

The following instruments were used in addition to the equipment provided by PictureTel to augment the system's diagnostic capabilities:

- Stethoscope: A Cardionics Simulscope bedside auscultation system was interfaced to the system to enable recording of heart sounds.
- Otoscope: An electronic otoscope was interfaced to the system to enable recording of internal ear examinations.
- Ophthalmoscope: An electronic ophthalmoscope was interfaced to the system to enable recording of eye examinations.
- Dermoscope: An electronic dermascope was interfaced to the system to enable recording of skin lesions and anomalies.

3. Telecommunications

Due to the topography and unavailability of land lines in some areas, a hybrid communications system consisting of microwave, fiber and copper was utilized. Figure 6 on the following page illustrates the video signal transmission route.

C. PROJECT PROCEDURES

For the purpose of this project, the NHCP Sports Medicine Clinic functioned as the consulting site, and the Area 52 Branch Clinic functioned as the referring site. The two PictureTel 4000EX units were connected in a dedicated point-to-point transmission mode. One PictureTel 4000EX system was located in the NHCP Sports Medicine's consulting suite. The Area 52 Branch Clinic's PictureTel 4000EX system was located in the examination room adjacent to the military sick-call section.

The PictureTel systems remained available for use with an active video communication link throughout the workday. Patient consultations were performed primarily in the morning hours during military sick call, and the system was utilized for medical education and inservice training during the afternoons.

If a physician or corpsman from the referring clinic wished to present a patient for consultation to the Sports Medicine Clinic, the referring health care provider at the Area 52 Branch Clinic's examination room addressed the consultant directly over the video link and the consultation commenced immediately. If a Sports Medicine Clinic staff member was not

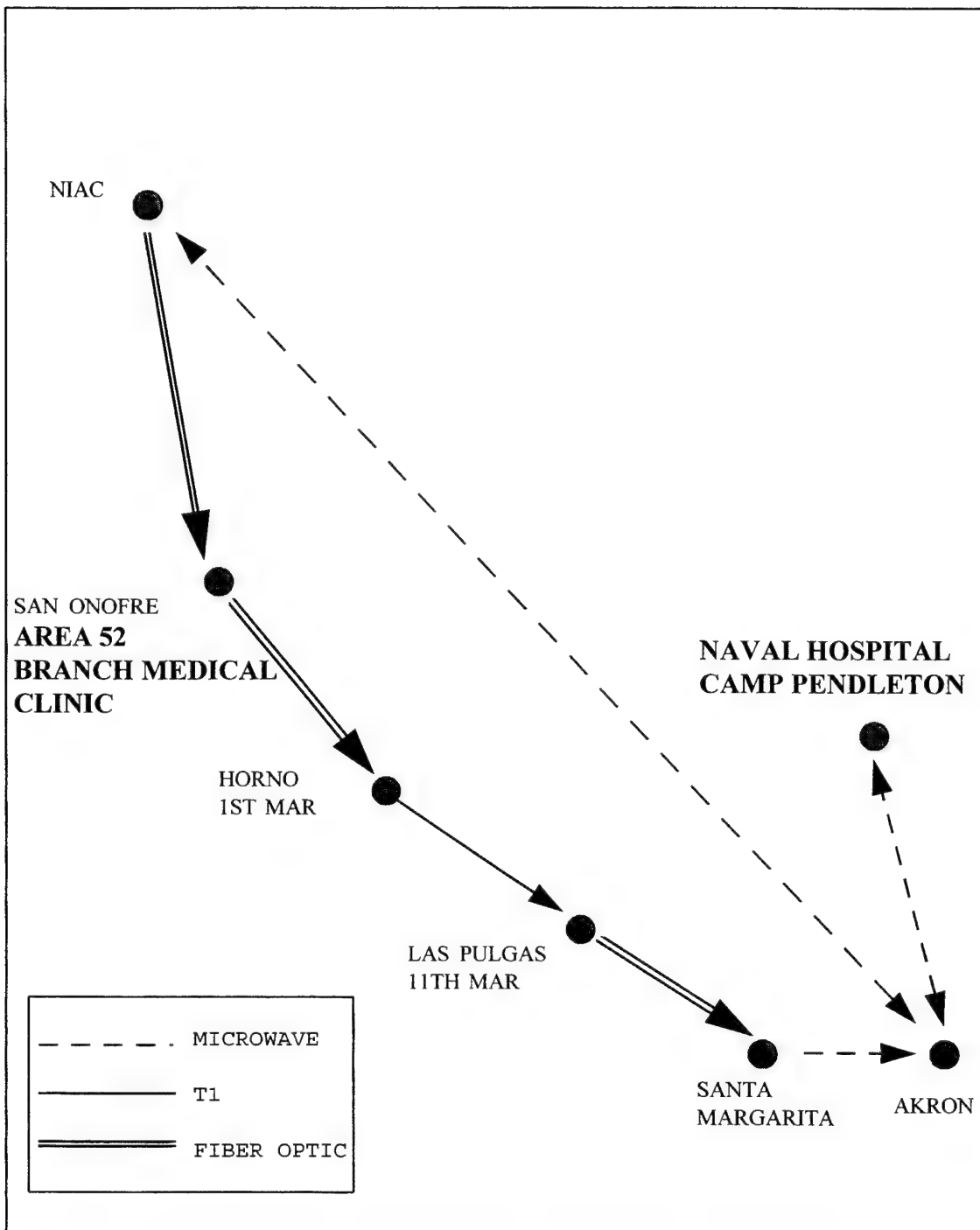


Figure 6. Naval Hospital Camp Pendleton Telemedicine Video Signal Transmission Route

present in the consulting suite, the referring clinic telephoned the Sports Medicine Clinic to request a telemedicine consultation.

The Sports Medicine Clinic provided primary expertise in musculoskeletal or orthopedic consultations associated with training or physical stress injuries. However, to extend the utility of the system, all patient problems were accepted for consultation. If a consultation required additional opinions in other specialties such as dermatology, psychiatry, otolaryngology, or ophthalmology, coordination between the Sports Medicine Clinic, the Area 52 Branch Medical Clinic, and the additional consulting clinics were required in order to provide the additional specialist in the consultation suite.

Consultations were recorded on videotape from the PictureTel unit in the consulting suite to document the patient interaction. Consulting physicians also documented the video consultation in the Composite Health Care System (CHCS), by entering the patient consultation into a CHCS terminal located adjacent to the PictureTel unit. The referring health care provider also recorded the patient's referral in the CHCS terminal at the Area 52 Branch Clinic.

D. DATA COLLECTION INSTRUMENTS

To evaluate project performance, several data collection instruments were created:

1. Patient Treatment Records

A patient logsheet was developed to record project data on the telemedicine interactions which included the following information:

- Primary patient complaint
- Acuity Level (urgent / non-urgent)
- Seriousness (major, differential, minor)
- Telediagnosis
- Additional studies required

- Disposition / confirmation

An example of the patient telemedicine project logsheet is included in Appendix E.

2. Patient Satisfaction Survey

A patient satisfaction survey for the telemedicine demonstration project was developed to record the patients' assessments of the telemedicine system, and to determine the impact of the telemedicine system on the patients' overall impression of their care. The survey was patterned after the Naval Hospital Camp Pendleton's Sports Medicine Clinic Patient Satisfaction Survey. An example of the patient satisfaction survey is provided in Appendix F

3. Telemedicine System Evaluation Survey

A telemedicine system evaluation survey was developed to assess the telemedicine consultants' positive or negative reactions to the telemedicine system. The project's system evaluation survey was patterned after the Draft Medical Defense Performance Review Video Teleconferencing Test and Evaluation Plan produced by the Mitre Corporation (Krajewski, 1994). An example of the telemedicine system evaluation survey is provided in Appendix G.

V. FINDINGS

A. EVALUATION OF COLLECTED DATA

1. Telemedicine Consultations

During a one month project evaluation period from mid-January through mid-February 1995, a total of 52 telemedicine patient consultations and 58 diagnoses were documented. Table 3 on the following page provides the telemedicine consultation summary data.

Consultations were provided by nine staff physician specialists at the Naval Hospital, Camp Pendleton. Patients were presented by two referring providers, a Chief Hospital Independent Duty Corpsman, and a general medical officer (GMO) on staff at the Area 52 Branch Medical Clinic. The referring and consulting providers used the telemedicine system evaluation survey to record their impressions of the system during the patient encounters. The majority of consultants rated the quality of moving images, the volume and ease of use of the control panel (key pad) as good or excellent. Two consultants (representing radiology and dermatology) rated the picture quality for diagnosis as poor.

The majority of the providers indicated that the telemedicine system had either no effect on the duration of the patient encounter, or slightly shortened the duration of the patient encounter. However, active duty patients seen via telemedicine returned to their unit an average of six hours earlier than those seen at the hospital through the traditional referral system.

The majority of consulting physicians and both referring providers recorded an overall impression of satisfactory when evaluating the patient disposition via tediagnosis.

2. Patient Satisfaction Survey Results

Patients were asked to provide a response to the following questions on a five point scale where a score of 1= strongly disagree, and a score of 5 = strongly agree:

DIAGNOSTIC CATEGORY	DIAGNOSIS	FREQUENCY
MUSCULOSKELETAL	Lower Extremity Strain/Sprain	8
	Stress Fracture (Foot)	5
	Stress Fracture (Tibia)	4
	Fracture Phalanx (Hand)	3
	Fracture Metacarpal (Hand)	2
	Internal Derangement (Knee)	2
	Stress Fracture (Femur)	1
PSYCHIATRY	Adjustment Disorder	7
	Depression	4
	Suicidal Ideation	3
PULMONARY	Asthma	6*
	Bronchitis	4
DERMATOLOGY	Herpes Genitals	2
	Viral Exanthem	1
	Epidermal Inclusion Cyst	1
OBSTETRICS	Routine Obstetrical Visit at 34 Weeks Gestation	1
SURGERY	Appendicitis	1
GENERAL MEDICINE	Diverticulitis	1
	Gastritis	1
NEUROLOGY	Seizure Disorder	1

Table 4. Telemedicine Consultation Summary Data.

* Spirometry data obtained and transmitted to specialist via telemedicine.

- 1) The staff projected a caring attitude and seemed willing to help in any way they could.
- 2) The length of time it took to be seen was reasonable.
- 3) My doctor took time to answer my questions.
- 4) I felt comfortable seeing the doctor over television.
- 5) I felt that the television system was as good as seeing the doctor in person.
- 6) I felt that the television system provided a good understanding of my medical problem for the doctor.
- 7) Overall, I was satisfied with the care.
- 8) I would choose to see the doctor over television in the future.

Table 5 below provides the patient survey summary data:

QUESTION	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
#1			4	19	19
#2		1	5	20	16
#3			2	17	23
#4	1			10	28
#5	1		3	8	27
#6	1		2	20	19
#7	1			11	30
#8	1		1	6	34

Table 5. Patient Satisfaction Survey Summary Data.

Of the 52 patients referred for telemedicine consultation, 42 surveys and 330 responses were received and evaluated. 93% of the responses were positive, 5% of the responses were neutral, and 2% of the responses were negative.

Positive, negative, and neutral responses listed by individual question are as follows:

<u>QUESTION</u>	<u>% POSITIVE</u>	<u>% NEGATIVE</u>	<u>% NEUTRAL</u>
#1	91	0	9
#2	86	2	12

#3	95	0	5
#4	97	3	0
#5	90	8	2
#6	93	5	2
#7	98	2	0
#8	96	2	2

The patient satisfaction survey findings indicate that 97% of the patients felt comfortable interacting with the physician over television, 90% agreed that the teleconsultation system was as good as seeing the physician in person, and 96% would choose to interact with the physician via telemedicine in the future.

The telemedicine patient satisfaction survey was designed to be similar in content and structure to the patient satisfaction survey instrument routinely used by the NHCP sports medicine clinic. Four of the eight questions employed to assess overall patient satisfaction on both surveys were identical. This was done to provide a basis for comparison of patient satisfaction response scores between the NHCP Sports Medicine clinic patients and the Telemedicine project patients to determine if the telemedicine aspect of care positively or negatively contributed to the patients' overall impression of care.

Responses from 93 patient satisfaction surveys conducted by the NHCP Sports Medicine clinic during May-October 1994 were compared to the 42 telemedicine (TMED) patient satisfaction survey responses collected for the project. Table 6 on the following page provides the two patient groups' responses to identical patient satisfaction questions:

The comparison of the two groups' responses indicates that the telemedicine system neither positively nor negatively impacted the patients' perception of staff attitude, the time spent in discussing the patients' medical problems, or the overall perception of care. Positive responses to the perception of reasonable waiting times was 9% lower in the telemedicine patient group. However, it should be noted that the NHCP clinic patient group

consists almost exclusively of civilian patients seen on a pre-scheduled appointment basis, while the telemedicine project group consists of military personnel in a sick call (walk-in/non-appointment basis). Since these two groups are widely dissimilar, it is not intended to use this information as a basis for statistical inference, but rather, to indicate in a qualitative sense that the introduction of telemedicine as a variable in patient treatment did not appear to have a large impact on the project participants' overall assessment of their care. In essence, both groups' responses reflect a positive attitude relating to their medical treatment.

PATIENT SATISFACTION SURVEY QUESTION	NHCP %POS	TMED %POS	NHCP %NEG	TMED %NEG	NHCP %NEUT	TMED %NEUT
The staff projected a caring attitude and seemed willing to help in any way they could	94	91	0	0	6	9
The length of time it took to be seen was reasonable	94	86	3	2	3	12
My doctor took time to answer my questions	100	95	0	0	0	5
Overall, I was satisfied with the care	97	98	0	2	3	0

Table 6. Comparison of NHCP Sports Medicine Clinic and Telemedicine Demonstration Project Patient Satisfaction Survey Responses.

A listing of individual patient satisfaction survey responses is provided in Appendix H.

3. Telemedicine System Education and Training Activities

Although the primary emphasis of most telemedicine projects is focused on direct patient consultation services, medical image transfers, and other medical technology applications, a major benefit of telemedicine lies in the capability to provide direct access to traditional continuing medical education (CME) and "instantaneous" CME accomplished through interactions between local and distant health care providers (McGee, 1994, p. 1134). In fact, a 1993 survey of telemedicine usage revealed that a typical interactive video

telemedicine system was used 75% of the time for on-line education and administration, leaving the remaining 25% of the time for medical consultations (Allen, 1993).

In each Navy medical center, hospital, and clinic, there are general CME courses that must be provided to satisfy the requirements of the Joint Commission on Accreditation of Health Care Organizations (JCAHO). Each Navy medical facility must also provide enlisted advancement CME courses for all Hospital Corps personnel. It is often difficult to provide the requisite courses to personnel assigned to remote or isolated medical treatment facilities. The NHCP telemedicine pilot project provided a number of enlisted advancement courses for Navy medical personnel at the Area 52 Branch Medical Clinic. The courses were provided over the video teleconferencing system by members of the NHCP Education and Training Department. A listing of the courses presented are provided below:

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
30 JAN Clinical Laboratory	31 JAN Medical Administration	1 FEB MMART	2 FEB Decedent Affairs	3 FEB Supply
6 FEB Preventive Medicine	7 FEB Clinical Sick-Call	8 FEB Pharmacy	9 FEB Health Records	10 FEB Dental
13 FEB Food Sanitation	14 FEB Anatomy and Physiology	15 FEB Patient Care	16 FEB Physical Examinations	17 FEB Food Management

Table 7. Continuing Medical Education Courses Presented via Telemedicine.

The CME courses presented via telemedicine enabled the staff personnel at the remote clinic to obtain the required training in their workspace without having to travel to the Naval Hospital.

In addition to presenting continuing medical education courses, the demonstration project also provided a health promotion class. A series of tobacco cessation classes were conducted over the telemedicine system during 17 January through 1 March 1995. A group of seven students, three at the remote clinic site and four at the hospital primary site, teleconferenced with two tobacco cessation facilitators who were co-located with the Naval Hospital students. One facilitator ran the classes and the other was responsible for controlling cameras and volume with a keypad. Three sessions were conducted. The student drop-out rate of 85% by the end of the course was consistent with previous tobacco cessation courses held at the Naval Hospital and with drop-out rates in the general population.

B. PROJECT COSTS AND BENEFITS

1. Project Costs

Project costs are provided in Tables 8 and 9 on the following page. Table 8 provides projections for equipment purchases, upgrades, and maintenance over a five year system life cycle. Table 9 discounts the project life cycle costs, using a 10% discount rate (average factor).

From Table 9 it can be seen that the cumulative discounted project costs for equipment acquisition and maintenance over five years are \$168,704.

2. Project Benefits

Tangible project benefits are based on cost avoidance enabled through the use of the telemedicine system. Cost avoidance is realized in three areas: 1) reduction in the number of lost training hours for SOI students through decreased hospital referrals, 2) reduction in the number of infantry instructor hours required to provide remedial training for SOI students who miss training evolutions due to hospital referrals, and 3) reduction in health care specialists' non-productive time spent in travelling between NHCP and the Area 52 branch clinic. Methods and assumptions used to calculate the cost-avoidance benefits are as follows:

COST CATEGORY*:	FY 95	FY 96	FY 97	FY 98	FY 99
PictureTel 4000EX System	70,640				
Communication Card	3,463				
Communications Multiplexer	5,000				
Communications Band	3,500				
Interface Cards	3,700				
Medical Add-On Equipment	17,300	5,000	5,000		
Installation / Maintenance	10,815				
Upgrades		1,000	1,000	1,000	
TOTAL ANNUAL EQUIPMENT COSTS:	114,418	6,000	6,000	6,000	
ANNUAL MAINTENANCE COSTS:		8,100	8,100	8,100	8,100
TOTAL ANNUAL COSTS:	114,418	20,100	20,100	15,000	8,100

Table 8. Telemedicine Pilot Project Costs.

	FY 95	FY 96	FY 97	FY 98	FY 99
System Costs	114,418	20,100	20,100	15,000	8,100
Discount Rate (10%)	1.000	0.955	0.868	0.789	0.717
Present Value	114,418	19,196	17,447	11,835	5,808
Cumulative Present Value	114,418	133,614	151,061	162,896	168,704

Table 9. Telemedicine Pilot Project Cumulative Discounted Project Costs.

* All costs in dollars

a. Calculation of Infantry Troop Student Hours Savings

This benefit is calculated by multiplying the number of telemedicine consults times the travel time avoided per troop enabled by the telemedicine consult, times the average hourly wage per troop:

$$\text{Troop Hour Savings} = (\text{Number of Telemedicine Consults}) (\text{Travel Time Avoided per Troop}) (\text{Hourly Wage per Troop})$$

Equation V.1. Troop Hours Savings

Travel time avoided per troop is assumed to be two hours (the approximate time in-transit for a round trip between the Area 52 branch clinic and the Naval hospital). The average hourly wage per troop is assumed to be \$10.00, based on an E-1 paygrade (Hourly wage is obtained from Navy Standard Personnel Management System (SPMS) pay tables).

b. Calculation of Infantry Instructor Hours Savings

This cost-avoidance benefit is calculated by multiplying the number of monthly telemedicine consults times the number of SOI troop hours saved per consult, times the number of troop companies affected, times the number of classes per year, times the instructor wage rate:

$$\text{Instructor Hours Saved} = (\text{Consults/Month})(\text{Troop Hours Saved/Consult}) (\text{Number of Companies}) (\text{Classes/Year}) (\text{Instructor/Troops}) (\text{Instructor Wage Rate})$$

Equation V.2 Instructor Hours Savings

Troop hours saved per telemedicine consult is again assumed to be two hours (the approximate time in-transit for a round trip between the Area 52 branch clinic and the Naval Hospital). Additional assumptions are: two companies affected, 12 classes per year (each SOI class is one month in duration), an instructor to student ratio of 1:30, and an instructor wage rate of \$13.00 per hour (based on an E-4 paygrade taken from SPMS pay tables).

c. Health Care Specialist Hours Savings

This cost-avoidance benefit is calculated by multiplying the average hourly wage rate of each health care specialist by the number of non-productive hours spent in transit between the Naval Hospital and the Area 52 branch clinic. The cost of vehicle transportation is also added to the avoided wages:

$$\text{Health Care Specialist Hours Saved} = (\text{Podiatrist Wages}) + (\text{Orthopaedist Wages}) + (\text{Sports Medicine Physician Wages}) + (\text{Psychiatric Technician Wages}) + (\text{Vehicle Transport Cost Savings})$$

Equation V.3 Health Care Specialist Hours Savings

The health care specialist travel time is assumed to be two hours per week (the time in-transit between the Naval Hospital and the Area 52 branch clinic). The costs are calculated as follows:

Podiatrist	(\$48.42 per hour) (2 hours per week) (52 weeks) = \$ 5036
Orthopaedist	(\$72.11 per hour) (2 hours per week) (52 weeks) = \$ 7499
Sports Medicine	(\$50.48 per hour) (2 hours per week) (52 weeks) = \$ 5250
Psychiatric Tech.	(\$13.00 per hour) (2 hours per week) (52 weeks) = \$ 1352
Vehicle Cost	(35 miles round trip) (\$.30 / mile) (52 weeks) = \$ 530
Total Salary and Transportation Cost Avoidance	\$19,667

Podiatrist, orthopaedist, and sports medicine physician wage rates are based on an O-5 paygrade. The psychiatric technician wage rate is based on an E-4 paygrade (from SPMS pay tables). The total cost-avoidance figure of \$19,667 annually assumes that all health care specialist travel to the Area 52 Branch clinic is replaced by telemedicine consultations. However, telemedicine consultations cannot be used as a substitution for specialist travel unless there are a sufficient number and mix of telemedicine consultations to support all specialty requirements. Therefore, this cost-avoidance benefit is adjusted with modification factors according to varying telemedicine consultation levels, provided in Table 10 on the following page. Table 11, also provided on the following page, provides

Consult Frequency	Total Potential Provider Cost Savings	Modification Factor	Adjusted Net Savings
Up to 2000 Annually	19,667	0.2	3,933
From 2000 - 3000	19,667	0.4	7,867
From 3000 - 4000	19,667	0.6	11,800
From 4000 - 5000	19,667	0.8	15,734
Over 5000	19,667	none	19,667

Table 10. Modification of Provider Cost Savings Based on Varying Telemedicine Consultation Levels.

FY 95 - FY 99 Cumulative Benefits (in dollars)*

Annual Consult	Troop Savings	Instruct Savings	Provider Savings	FY 95	FY 96	FY 97	FY 98	FY 99
1000	20000	1709	3933	25642	50130	72387	92619	111004
1100	22000	1874	3933	27807	54363	78499	100439	143331
1200	24000	2059	3933	29992	58634	84667	108331	154593
1250	25000	2141	3933	31704	60750	87722	112239	160171
1275	25500	2183	3933	31616	61809	89252	114197	162964
1300	26000	2224	3933	32157	62867	90779	116151	169661
1350	27000	2306	3933	33239	64982	93833	120059	175239
1400	28000	2388	3933	34321	67098	96889	123968	176908
1500	30000	2574	3933	36507	71371	103059	131863	188175
2000	40000	3418	7867	51285	100262	144777	185241	264348
2200	44000	3768	7867	55635	108766	157057	200953	286769
2500	50000	4283	7867	62150	121503	175449	224485	320351
3000	60000	5148	11800	76948	150433	217224	277936	396628
4000	80000	6856	15734	102950	200563	289611	370555	528799
5000	100000	8565	19667	128232	250694	361999	463174	660972

Table 11. Telemedicine Project Cumulative Benefits at Varying Consultation Levels.

* FY 95 - FY 99 benefits reflect present values calculated at a discount factor of 10%

cumulative tangible project cost -avoidance benefits using equations V.1, V.2, V.3, and the modified provider cost savings in Table 10.

3. Project Costs Versus Benefits

Using the costs contained in Table 9 and the benefits contained in Table 11, the potential costs and benefits over the project life cycle can be evaluated. Table 12 compares the cumulative costs and benefits:

Annual Telemedicine Consultation Level	Cumulative Costs FY 95 - FY 99	Cumulative Benefits FY 95 - FY 99	Project Net Present Value
1000	168704	111004	-57700
1100	168704	143331	-25373
1200	168704	154593	-14111
1250	168704	160171	-8533
1275	168704	162964	-5740
1300	168704	169661	957
1350	168704	175239	6535
1400	168704	176908	8204
1500	168704	188175	19471
2000	168704	264348	95644
2200	168704	286769	118065
2500	168704	320351	151647
3000	168704	396628	227924
4000	168704	528799	360095
5000	168704	660972	492268

Table 12. Telemedicine Project Net Present Values at Varying Consultation Levels.

From Table 12, the number of telemedicine consultations must approach 1300 per year in order to produce a positive net present value for the project life, considering equipment acquisition and maintenance costs. These costs, however, do not provide for any personnel in support of the telemedicine providers or the telemedicine system itself. The

telemedicine system resources, like other medical information system resources, require administrative and clinical personnel assets. Consultation schedules must be developed and maintained, as well as consultation procedures and protocols. Coordination and liaison between various specialty consultants and their facilities is also required to maintain the efficiency of the telemedicine consultation process. Finally, telemedicine patient consultation records must be organized and maintained. Table 13 introduces estimated support personnel costs in terms of full-time equivalents (FTEs) at varying telemedicine consultation levels.

Annual Consult Level	Equip/Maint Cumulative Costs	Support FTE	Support FTE Costs*	Cumulative Benefits	Project Net Present Value
1000	168704	0.25	29264	111004	-86964
1100	168704	0.25	29264	143331	-54637
1200	168704	0.25	29264	154593	-37797
1250	168704	0.25	29264	160171	-37797
1275	168704	0.25	29264	162964	-35004
1300	168704	0.25	29264	169661	-28307
1350	168704	0.5	58529	175239	-51993
1400	168704	0.5	58528	176908	-50324
1500	168704	0.5	58528	188175	-39057
2000	168704	0.5	58528	264348	37116
2200	168704	0.5	58528	286769	59537
2500	168704	0.5	58528	320351	93119
3000	168704	1.0	117057	396628	110867
4000	168704	2.0	234114	528799	294685
5000	168704	3.0	351171	660972	309801

Table 13. Telemedicine Project Net Present Values at Varying Consultation Levels Including Support Personnel Costs.

*FTE (Full Time Equivalents) calculated at an E-4 equivalent paygrade, using a 10% discount factor over the five year life of the project

From Table 13, the number of telemedicine consultations must approach 2000 annually to achieve a positive net present value when considering additional costs associated with support personnel.

The average number of annual Marine Corps School of Infantry patient referrals from the Area 52 branch clinic to Naval Hospital specialty clinics is approximately 20,000, according to the Naval Hospital, Camp Pendleton Plans, Programs and Analysis (PP&A) fiscal year 1994 branch medical clinic workload report. Assuming that one out of four, or 25% , of the hospital referrals can be prevented by telemedicine consultations, a potential of 5000 telemedicine consultations can be generated annually. Using the data projected in Table 13, the telemedicine system can theoretically produce a net present value of \$309,801 over a five year system life cycle at a level of 5000 consultations per year.

VI. CONCLUSIONS

A. SUMMARY OF FINDINGS

In this section, the findings of the Naval Hospital, Camp Pendleton telemedicine pilot project, and the findings collected through the review of current ongoing efforts in the Navy telemedicine initiative described in chapter III will be used to provide answers to the research questions proposed in this thesis.

Does the Navy telemedicine initiative support assigned or implied operational missions? Yes. The research findings indicate that the focus and scope of current efforts are designed to provide direct support to operational elements of the Navy and Marine Corps. The Naval Hospital, Camp Pendleton pilot project successfully demonstrated the feasibility of real-time, interactive, 2:2 remote diagnostic support for a variety of clinical problems in the areas of musculoskeletal injuries, psychiatry, pulmonary medicine, dermatology, surgery, neurology, and general medicine. The Naval Hospital, Camp Pendleton telemedicine project provided direct support to Marine Corps training units and established the capability to reduce the amount of lost training time by improving the management of low-acuity medical problems in the local treatment area and averting unnecessary patient referrals. Other Navy telemedicine efforts have demonstrated similar operational mission support benefits, such as the *Challenge Athena II* demonstration project in which telemedicine consultations prevented an estimated 31 medical evacuations from the USS George Washington, enabled the ship's medical department to provide extended medical care, and enabled the medical department to more effectively manage difficult clinical cases. The telemedicine project in place at the Naval Medical Center, San Diego, provides direct support to the Navy's Fleet Hospital Six which supports the operational mission, *Provide Hope* in Zagreb, Croatia, and the telemedicine project operating at the National Naval Medical Center in Bethesda, Maryland provides support to a Navy OCONUS hospital located in Guantanamo Bay, Cuba.

Does the Navy telemedicine initiative proactively focus on developing total access for difficult-to-serve, expensive-to-serve and under-served patients who rely on military medicine for prevention, diagnosis and treatment? Yes. The NHCP telemedicine pilot

project was specifically designed to demonstrate the capability to support a remotely located, difficult-to-serve, and expensive-to-serve patient population. The project successfully implemented a complex hybrid communications system utilizing microwave, fiber optics and copper, which delivered telemedicine support to a remote location and extended the expertise of nine specialty consultants into a difficult-to-serve area. This patient population was also expensive to serve when considering the transportation costs and lost training hours associated with the traditional hospital referral system. Other Navy telemedicine efforts have also focused on difficult to serve, and expensive-to-serve patient populations. The Naval Medical Center, San Diego, provides teleradiology support to a distant fleet hospital in Zagreb, Croatia. The National Naval Medical Center in Bethesda, Maryland, provides teleradiology support to the USS George Washington at sea, as well as teleradiology and video teleconferencing support to the U.S. Naval Hospital in Guantanamo Bay, Cuba.

Does the Navy telemedicine initiative provide process re-engineering for development of new medical practices and advanced technology applications? No. There is no evidence to indicate that process re-engineering has been incorporated into the Navy telemedicine initiative. Earlier in this thesis, it was stated that the first generation of telemedicine systems were considered to be tools rather than information systems to be integrated with existing services. Evaluation of the Naval Hospital, Camp Pendleton pilot project, as well as a review of the current efforts in the Navy telemedicine initiative indicates that projects are fielded as "stand-alone" demonstrations with limited clinical objectives and small target populations. Although the Navy has articulated a general strategy for implementing widely-deployed telemedicine capabilities, there is no specific business plan for the integration of telemedicine-provided services with existing practices. For example, there is no plan for integration of telemedicine with the Department of Defense's Composite Health Care System (CHCS). CHCS, currently in the deployment phase, will be used by all military treatment facilities world-wide to automate the DoD health care system. The utility and effectiveness of telemedicine will be severely limited without a plan for integration with CHCS. Re-engineering involves business integration which includes aligning strategy,

people, technology, and business processes to significantly cut costs, reduce non-value-added work, and streamline organizations (Sprague, 1993, p. 89). Unless these four elements are synchronized, the benefits of telemedicine technology may not be realized. Each telemedicine effort should be designed to be an integrated process within the health care system, rather than a stand-alone tool designed to demonstrate a limited set of technical or clinical capabilities.

Does the Navy telemedicine initiative provide measurable, reproducible improvement of outcomes? Yes. Although results are preliminary and efforts to date have focused on a limited set of clinical applications with small target populations, the findings from the Naval Hospital, Camp Pendleton pilot project as well as the results from *Challenge Athena II* and project *Provide Hope* indicate that telemedicine support consistently enables referring sites to more efficiently manage low-acuity clinical problems, and more effectively manage complex clinical problems. The findings indicate that patients presenting with low-acuity clinical problems are returned to duty in a shorter period of time through telemedicine consultations than through traditional referral methods. The findings also indicate that telemedicine interactions reduce the sense of professional isolation for referring providers at remote locations, and that telemedicine-provided continuing medical education activities improve the skills of providers at remote locations.

Is the Navy telemedicine initiative designed to achieve interoperability, scalability, and upgradeability? No, not in the current environment. As discussed in the telemedicine technology overview, a number of competing proprietary solutions developed by telemedicine equipment manufacturers are currently superior to the Telecommunications Standards Sector (TSS)-developed standards. This creates a disincentive for interoperability. There are in excess of 50 vendors of teleradiology equipment and few of them use the same compression algorithm (Allen, 1995, p. 5). This is a telemedicine industry problem that needs to be addressed. As computer networks and communications technologies develop, both their vertical and horizontal integration will be critical. Current hardware and software development strategies, including those in the telemedicine area, often build on competition

rather than on cooperation among developers (McGee, p. 1134, 1994). Technologic standards in the delivery of telemedicine must be established. Professional groups within the medical community are most capable of developing these standards. Rather than emphasizing the maximal capabilities available, medical personnel should focus on the minimal acceptable standards to ensure quality but minimize costs. Until this occurs, interoperability, scalability, and upgradeability cannot be assured.

The Navy's communications integration concept for telemedicine discussed in Chapter III provides a basic underlying strategy upon which to build interoperability, scalability, and upgradeability. However, the specific implementation policy and procedures have yet to be developed.

Is the Navy telemedicine initiative leveraged through outreach and collaboration with academia, industry and other governmental agencies? Yes. The Navy is actively collaborating with academia, including participation in the North Carolina Health Care Information and Communication Alliance and the Saint Francis College Center for Remote and Medically Underserved Areas (CERMUSA) Project (See Appendix B). As part of its guiding principles, the Navy telemedicine initiative is also committed to the use of commercial off the shelf (COTS) equipment. The telemedicine equipment utilized in the NHCP pilot project was provided by the PictureTel Corporation through a hardware testing and evaluation agreement.

It should be noted, however, that little evidence of Navy participation in Army and Air Force telemedicine projects was found during this research. Although the Navy Surgeon General participates as a member of the DoD Telemedicine Test Bed Board of Directors, there appears to be few Navy personnel assets committed to the tri-service telemedicine effort at the Army's Medical Advanced Technology Management Research and Matériel Command, (MATMO), which is functioning as the executive agent for the DoD telemedicine effort.

Is the Navy telemedicine initiative managed to reflect sound business practices? Yes. The Navy's current operational strategy is focused on implementation of pilot projects

at field activities to demonstrate initial telemedicine capabilities. This is a conservative approach which is sound from a business perspective when considering that telemedicine is a developing technology which has not been tested on a large scale, and like any developing technology, is associated with a significant degree of risk. Well-focused pilot projects require relatively small investments in terms of resources, thereby minimizing the risk in the event of failure. It was shown in Chapter V that the Naval Hospital, Camp Pendleton telemedicine pilot project can potentially generate a net present value of approximately \$300,000 over a five year system life cycle with a relatively small investment of approximately \$170,000. The telemedicine project conducted aboard the USS George Washington generated an estimated \$85,000 in tangible benefits through the avoidance of medical evacuations off the ship due to telemedicine support.

The disadvantage in the conservative business approach is the opportunity costs foregone when investing cautiously in the implementation of a developing technology that promises to yield large benefits relative to its costs. This is especially significant when there is great internal and external pressure placed on the organization to increase efficiency in business processes. From the information presented in this thesis, it was shown that the Navy has much to gain from telemedicine due to the forward-deployed nature of the Navy and Marine Corps' mission at sea. Based on the results of the initial telemedicine demonstration projects, telemedicine presents the promise of yielding large benefits that can no longer be obtained through traditional incremental solutions involving increased health care personnel resources and construction of new facilities. Therefore, the strategic plan to integrate telemedicine into the Navy's existing health care services system should be accelerated, and the business processes targeted as appropriate for telemedicine should be re-engineered and deployed to leverage the benefits of telemedicine technology to the widest extent possible.

B. LESSONS LEARNED

The potential benefits of telemedicine arise from the substitutions made possible by telecommunications and computer technology. These substitutions include site of care, type of provider rendering services, and the content and process of care. The technology allows the interaction and exchange of information between geographically separated participants as a substitute for face-to-face contact. Diagnostic procedures, clinical consultations, and continuing medical education can be conducted without negatively affecting the quality of information exchanged, effectiveness of education, or the safety of the patient being treated (Bashshur, 1994, p. 10).

The intrinsic value of telemedicine is gained from the ability to distribute and control the use of medical services to achieve the maximum benefits. The control or use of a service should be based on a process which encourages appropriate use of the service (by diminishing or removing distance and time barriers), while discouraging inappropriate use (by providing reasonable disincentives).

High speed equipment is not a prerequisite for adjunctive telemedicine applications. Telemedicine is useful in incremental stages, even with low-level technologies and for portions of the total diagnostic picture (Berek and Canna, p. 11, 1994). All forms of telecommunications, not just high-end video systems, can be utilized in new telemedicine applications. However, all telemedicine applications, regardless of the technological approach or scope, must be viewed within the context of the larger strategic planning or systems perspective. Business processes must be designed and integrated to provide the most efficient and effective solution to the problems of cost, quality, and access facing all health care delivery systems. In overall assessments, it may be easier to determine "what is state-of-the-art equipment" rather than "what is the simplest system that will do the job." New video technologies that use fiber optics or satellite communications can provide extensive high-bandwidth services. In many instances, however, simpler, less costly alternatives will function well for specific applications. If only the most sophisticated current technologies are explored for telemedicine, the costs will most likely be prohibitive. Technologies such as the telephone, existing computer networks, microwave, or broadcast

television can all have important roles in telemedicine (McGee, 1994, p. 1134). The medical community, providers of technology, and telecommunications companies must share the responsibility for identifying the most appropriate and cost-effective technology for each application.

Effective telemedicine can improve the ability of mid level practitioners (for example, independent duty corpsmen) to participate in health care delivery in remote areas. Mid level practitioners are an important resource in the Navy health care system, especially in remote clinics and shipboard environments, where physician support is limited or absent. Telemedicine can leverage the effectiveness and expand the capabilities of the mid level provider.

Telemedicine is a viable option for systems with limited resources, as seen in the Naval Hospital, Camp Pendleton pilot project. In these circumstances, telemedicine may enable a more efficient cost per service mix.

When the health care provider is responsible for the total cost of the care, which is the case in military medicine, the economic benefit of telemedicine is significant. Accounting for lost opportunity costs (and other external factors such as travel) will help demonstrate the cost advantage of telemedicine programs.

When investigating the feasibility of a telemedicine system, consideration should be given to including nonclinical services, such as continuing medical education programs and administrative communications.

Telemedicine can provide a screening or triage mechanism by which low-acuity cases can be maintained in the immediate area and complex cases can be referred to specialists in tertiary care settings with the resources to manage them.

A decrease in a sense of isolation is a readily observable benefit of telemedicine extended to remote facilities. Isolation, both professionally and socially, is known to contribute to dissatisfaction among health care providers in remote areas (McGee, p. 1134, 1994). Effective use of telemedicine has been shown to decrease perceptions of isolation.

Using telemedicine, consulting centers can deliver quick and efficient patient services without the overhead costs of bringing and keeping patients on site. According to the initial survey data generated by the Naval Hospital, Camp Pendleton pilot project, patients are satisfied with telemedicine interactions, and providers are satisfied with the clinical outcomes and patient dispositions resulting from telemedicine consultations.

The broader issue of the value of telemedicine in support of remote and isolated facilities should be judged on the basis of more than the traditional analysis of costs and benefits. Assessments of the value of telemedicine should also consider other factors such as quality-of-life factors for providers and patients in the remote locations, advantages of preventive medicine brought about by improved health education through telemedicine, and the long-term influence of multi-functional systems that improve the quality of care and improve the level of access to consultative services. Although these variables appear complicated to assess, they can be modeled and estimated (McGee, p. 1136, 1994). Ultimately, they may be the most important determinants of the contributions of telemedicine.

C. SUMMARY

The federal government and private insurers have applied numerous "band aid" initiatives to slow the growth of the health care industry's rapidly increasing costs. But no major national reforms have taken place, and there has been little formal evaluation of the role telecommunications can play in a national reform effort (A.D. Little, 1992, p. 9).

Interactive video for patient consultations is still in a developing stage, with most programs relying on large subsidies for their existence. While enormous investments have been made in equipping telemedicine programs, the levels of usage for patient-care activities have been disappointingly low. Surprisingly, the majority of usage for most systems has not been for patient-care activities. Instead, a typical interactive video telemedicine system will be used 75% of the time for on-line education and administration, leaving the remaining 25% of the time for medical consultations. In a survey performed during 1993, it was found that there were less than 2000 patient-physician consultations in all of North America, or about

five per day. Of these, half were three to five minute renal dialysis consultations done at one rural nephrology clinic in Texas. The remainder were more standard 25-35 minute consultations, comprising primarily psychiatry, dermatology, cardiology, neurology, and oncology. The relatively small numbers are very surprising, when considering the installed base of telemedicine equipment at that time amounted to many millions of dollars (Allen, 1995, p.3).

More recent surveys focusing on other aspects of telemedicine found that in the first six months of 1994 there were approximately ten programs in North America offering interactive videoteleconferencing health services, predominantly in psychiatry. These programs saw a total of approximately 484 consultations, of which nearly half were seen at one clinic in Nebraska. In reviewing the current state of implementation of interfacility teleradiology, it was found that there are about 11 such programs in North America, serving about 92 remote sites. In the first six months of 1994, a total of approximately 21,000 cases were read, equating to slightly less than 50,000 per year. A normal year's caseload for a full time radiologist is about 10,000 cases. Therefore, in all of North America, the current volume of interfacility teleradiology traffic would support only five teleradiologists (Allen, 1995, p. 3).

Other countries that have been more successful in limiting health care expenditures are experimenting with the use of telecommunications to reduce the cost of care. For example, Japan funds several telecommunications research and pilot programs. The Kyoto Prefectural University of Medicine is the only site in the world that has used high definition television (HDTV) in providing medical care. Italy is sponsoring development of a national telecommunications infrastructure. The province of Ontario, Canada, in an experiment with smart cards, has reduced unnecessary hospitalizations due to medication contraindications. The European Community's Advanced Information in medicine program is funding several demonstration programs in Picture Archival and Communications Systems (PACS) and smart cards, and is developing standards for an electronic medical record and distributed architectures (A.D. Little, 1992, p. 10).

The knowledge of telemedicine's true effects currently lags behind the many initiatives underway to establish telemedicine systems in various parts of the country and the Department of Defense. Despite the designation as a "second generation", telemedicine is still an immature technology. Empirical research and evaluation are just beginning. Therefore, it will be some time before any valid data can serve as a foundation for telemedicine policy. The opportunity now exists to develop a strategic planning agenda for telemedicine research that will provide the needed scientific knowledge base to address the critical policy issues surrounding telemedicine's effects on the health care system.

D. RECOMMENDATIONS FOR FUTURE RESEARCH

As part of the strategic planning process, basic research is needed to determine integration requirements for telemedicine within the Navy health care delivery system. Telemedicine has the capability to provide an unprecedented variety of information in a number of formats including still images, video images, and sound. The integration of telemedicine-generated multi-media information with existing automated systems such as the Composite Health Care System (CHCS) is of critical importance in the establishment of a comprehensive electronic medical record. Important issues in this research initiative are requirements for telemedicine data storage, data compression, information retrieval, and user-interface and display devices.

An equally important research requirement closely related to information integration is the need for development of minimal technologic standards in the provision of telemedicine services. Professional groups within the medical community working with providers of technology and telecommunications organizations need to work together to enable the vertical and horizontal integration of telemedicine information systems through the development of system standards.

Additional research on the quality of care achieved with telemedicine is also needed. Although preliminary studies have indicated that the quality of care provided by telemedicine can be equal to the care received in the conventional health care system, additional research is needed for a more thorough evaluation of quality. Telemedicine system planners should

actively engage in dialogue with investigators and providers to identify research questions and design appropriate studies to evaluate quality.

The development of a telemedicine infrastructure within the Navy health care system can potentially create an interactive communications network with multi-media information access available to beneficiaries. This infrastructure can enable health care consumers to communicate with their clinicians and peers effectively and provide consumers with pertinent and timely information on health care issues. Access to this information can empower health care consumers to more effectively manage their own health and proactively seek relevant information. In this way, telemedicine can be used to shift the role of health care providers from treating sick patients in hospitals and clinics to managing the health of people in their own homes and work places. Research is needed to develop mechanisms that will provide access to the network of health resources available through telemedicine from the health care consumers' perspective, and to develop mechanisms for motivating consumers to utilize telemedicine information resources to more effectively manage their own health and thereby decrease the escalating cost of providing care.

APPENDIX A. LISTING OF TELEMEDICINE ORGANIZATIONS

Advanced Telemedicine Research Group

Douglas A. Perednia, M.D.
Biomedical Information and Communication Center, Oregon Health Sciences University
Portland, OR 97201-3098
(Voice) 503-494-6846 (Fax) 503-494-4551
perednia@ohsu.edu

The Advanced Telemedicine Research Group is performing basic research into the specification and design of an economical and useful teledermatology system. Factors to be studied include the spatial and color resolutions required, the application of image compression schemes made practical by use of high-speed computing; equipment needed to produce acceptable results over a wide area network; and protocols for skin image transmission and storage for clinical or research use. Three rural sites in Oregon have been chosen to participate.

American Telemedicine Association (ATA)

Jane Preston, M.D., Director
P.O. Box 200195
Austin, TX 78720
800-899-1101
512-480-2247
(Fax) 512-480-2248

Incorporated in April 1993 by members of pioneering telemedicine projects, the ATA is committed to promoting telemedicine in health care and civic communities and coordinating telemedicine standards activities. The ATA objectives are national in scope: (1) to drive public policy regarding reimbursement, and (2) to promote telecommunications industry interest in rural dispersal of transmission capability.

Center for the New West

Leslie Sandberg
600 World Trade Center, 1625 Broadway, Denver, CO 80202
(Voice) 303 572-5400 (Fax) 303 572-5499

The Center for the New West is an independent, nonprofit research institute focusing on trade, technology and economic development. The center studies telemedicine policy development and analysis of technology, regulatory and ethical issues; how telemedicine can

reduce health care costs, and development of cost benefit analysis and other economic models for users of telemedicine.

Center for Advanced Telemedicine Research (CATR)

Douglas Perednia, M.D., Director
CATR, OHSU/BICC
3181 SW Sam Jackson Park Road
Portland, OR 97201-3098
503-494-4502
(Fax) 503-494-4551
perednia@ohsu.edu

CATR is involved in research activities, promotes collaborative efforts in telemedicine research, and functions as an information clearinghouse for telemedicine projects. It provides links from institutions to industry involved in technology transfer initiatives.

Center for Public Service Communications (CPSC)

Neal Neuberger
1600 Wilson Boulevard, Suite 500
Arlington, VA 22209
703-528-0801
(Fax) 703-528-0802
jscott@access.digex.net

CPSC was established to support educational, scientific, health, and humanitarian organizations in applying new communications and information technologies to their programs. CPSC provides consulting and advocacy services to government and international agencies and private sector firms. Clients come to CPSC for an unbiased perspective on the numerous available telecommunications and information technologies. CPSC advises on issues of cost, obsolescence, competition, viability, regulation, maintenance, equipment, compatibility, and program production and distribution. CPSC also continually tracks current technical and regulatory developments in the telecommunications industry and serves as a clearinghouse for telecommunications-related information to its clients.

Clinical Telemedicine Cooperative Group (CTCG)

Douglas Perednia, M.D., Director
Oregon Health Sciences University, BICC
3181 SW Sam Jackson Park Road
Portland, OR 97201-3098
503-494-6846 perednia@ohsu.edu

CTCG provides an infrastructure necessary to consolidate the outcome and clinical efficacy data from a group of telemedicine projects to create larger pools of research data. Structure of the CTCG is modeled on the Southwest Oncology Group (SWOG), which pools data for oncology research.

Consumer Interest Research Institute (CIRI)

Mary Gardiner Jones, Director
1631 Sutter's Lane NW
Washington, DC 20007
202-333-6035

CIRI is a Washington-based public policy education organization founded in 1982 to promote consumer interest in emerging technologies. The institute currently is disseminating an educational piece called "21st Century Learning and Health Care Services in the Home," which deals with distance learning and telemedicine.

Innovative Medical Communications (IMC)

Jim Reid, PA-C, Principal
P.O. Box 80691
Billings, MT 59108-0691
406-698-6855

IMC provides consulting in telemedicine including needs and assessment, project planning, design, implementation, and operation. It also provides conceptual education for administrative and medical staff and network and equipment vendor relations.

Institute for Telemedicine

Center for the New West
Betsey S. Blakeslee, Ph.D., Managing Director
600 World Trade Center
1625 Broadway
Denver, CO 80202
303-572-5400

The Institute for Telemedicine is a nonprofit institute supported by public and private funding to promote telemedicine technology. The institute is focusing on initiatives in the following areas: applications, education, technology transfer, economic development, industry affiliations, cost analysis, and public policy development.

Telemedicine Interactive Consultative Services (TICS)

Jane Preston, M.D., Executive Director
P.O. Box 200195
Austin, TX 78720
512-480-2243
(Fax) 512-480-2248

Founded in 1985, TICS is a nonprofit group dedicated to influencing public policy on telemedicine. It conducts feasibility studies on the cost-effectiveness of pilot programs in hopes of ultimately obtaining global funding for telemedicine services.

Telemedicine Research Center(TRC)

John Kadel
7276 SW Beaverton-Hillsdale Highway, Suite 187
Portland, OR 97225-2098
(Voice) 503-321-2233
kadelj@ohsu.edu

TRC is a non-profit organization dedicated to fostering collaborative telemedicine research. TRC Sponsors the Clinical Telemedicine Cooperative Group, and the Telemedicine Information Exchange (TIE), TRC supports an electronic resource on the Internet which provides access to information about telemedicine applications across the United States and internationally.

Telemedicine of North America, Ltd. (TNA)

Oklahoma Medical Research Foundation

James S. Logan, M.D.
825 N.E. 13th Street
Oklahoma, OK 73104
405-271-1175
(Fax) 405-271-1178

Telemedicine of North America provides consultative services in needs assessment, design, implementation, operation, and evaluation of telemedicine systems. TNA provides assistance in developing a systematic plan that addresses the management, organizational, and medical framework necessary for successful deployment of a telemedicine system.

APPENDIX. B. LISTING OF TELEMEDICINE PROJECTS BY STATE

The information contained in this appendix was obtained from the Telemedicine Research Center (TRC), an independent not-for-profit public service medical research corporation based in Portland, Oregon. TRC provides a Telemedicine Information Exchange (TIE) that may be accessed through the Internet at the Universal Resource Locator (URL) address: <http://tie.telemed.org>

ARKANSAS

University of Arkansas for Medical Sciences (UMAS)
4301 Markham, Slot 599, Little Rock, AR 72205

Contact: Ann Bailey Bynum, Ed.D, Associate Director, Area Health Education Centers Program; - (501) 686-2590 (voice) - (501) 686-2585 (fax) - abbynum@life.uams.edu (e-mail)

System: Interactive video

Interactive video Applications: Trauma, emergency room, cardiology, radiology, mental health, substance abuse, dermatology, pediatrics, obstetrics and gynecology, orthopedics
Technologies:

Four intracampus sites linked by fiber optics; five area health education centers (AHECs) and seven affiliated rural hospitals linked by T1 lines

Vendors: VTEL

Funding: University and state support; \$1.5M investment in network

Project Summary: The UAMS Telemedicine/Health Sciences Program's role and scope includes: improving access to specialty care through the provision of telemedicine consultations to rural Arkansans by health care specialists, as requested by primary care practitioners; improving the quality of emergency care, through around-the-clock interactive television connections of affiliated rural hospitals to the emergency center at UAMS; providing a multidisciplinary health professional leadership component for the overall UAMS outreach initiative that utilizes telecommunication technology; improving the state's system of health care delivery, through the development of interactive television networks that can be replicated in other rural areas. The UAMS network is part of STARNET (State of Arkansas Network), which now totals 38 sites including several hospitals and colleges.

CALIFORNIA

Scripps Memorial and Mission Bay Memorial Hospitals.
Healthcom, 10915 Technology Place, San Diego, CA 92127

Contact: Vincent S. Kluth, Manager, Healthcom; - (619) 592-5521 (voice)
kluth@gdwest.gd.com (e-mail)

System: 2-way interactive video

Technologies: 2-way audio/video, T1 Wide Area Network

Vendors: RMCS by Healthcom

Project Summary: A demonstration telemedicine research project using a remote medical consultation system (RMCS). Mission Bay's emergency room physicians can consult, in real time, with Scripps' trauma doctors using an existing T1 WAN. Each site's doctors use live 2-way audio/video, vital signs, digitized x-rays and patient records to evaluate the system's potential for remote triage, diagnosis and patient management decisions.

COLORADO

High Plains Rural Health Network (HPRHN) and Telemedicine Alliance of Healthcare Organizations (TAHO)

218 E. Kiowa Avenue., Fort Morgan, CO 80201

Contact: Ed Bostick, Executive Director; Steve Mecklenburg, Telemedicine Project Director; - (303) 867-6195 (voice) - (303) 867-5579 (fax) - Steve Mecklenburg smeck@hprhn.org (e-mail)

System: Store and forward and Interactive

Applications: Teleradiology, cardiology, dermatology, mental health, obstetrics gynecology, orthopedics and trauma.

Technologies: Compressed Video, Single monitor Stand-alone computers for Internet access

Vendors: VTEL

Funding: Office of Rural Health Policy, \$1.5M over 3 years

Project Summary: TAHO was formed after the ORHP awarded High Plains Rural Health Network a 3 year grant to implement a three state telemedicine network. HPRHN is a non-profit organization of health care providers incorporated in 1990. The TAHO telemedicine network will provide videoconferencing capabilities for medical professionals including stand alone capabilities for Internet and E-Mail access. The system will have live, interactive video and store and forward capabilities. This system is designed as an open system so that as new members join HPRHN they can be easily added to the telemedicine network. Initially the project includes the states of Colorado, Kansas and Nebraska and will connect 10 rural/frontier facilities with two tertiary specialist hospitals. The specialties available include: teleradiology, cardiology, dermatology, mental health, obstetrics and gynecology, orthopedics, and trauma. The Internet and e-mail access will provide the opportunity for physicians in rural/frontier areas to access databases and communicate with fellow care givers in new and exciting ways.

CONNECTICUT

Americare, Incorporated
161 Cherry St., New Canaan CT 06840

Contact: John Riehl, Exec. Director; - (203) 966-5195 (voice) - (203) 966-7945 (fax)

Applications: General medicine, emergency consultations

Project Summary: This telemedicine system is designed to operate between Norwalk Hospital and Americare Clinic, a walk-in clinic in an underserved area in New Canaan. Americare is an international company which delivers donated medical equipment and goods. The project will include physical exams and some emergency room consultations. The hospital and clinic are 4 miles apart.

FLORIDA

University of Miami School of Medicine, Department of Dermatology and Cutaneous Surgery
P.O. Box 016250 (R-250), Miami, FL 33101

Contact: Anne E. Burdick MD, MPH, and Brian Berman, MD, PhD; - (303) 547-5620 (voice) - (305) 547-6468 (fax) - aburdick@mednet.med.miami.edu and bberman@mednet.med.miami.edu (e-mail)

System: Store and forward and interactive video

Applications: Dermatology Technologies: video cameras, lightweight portable desktop video screens, dedicated wiring using ISDN lines, CODEC video technology

Vendors: Equipment donated by AT&T, Hitachi Telcom, Sony and Southern Bell

Project Summary: In April 1991 a project was initiated to create an interactive telemedicine link between specialists at Jackson Memorial Hospital/University of Miami Medical Center (JMH) and patients at the Martin Luther King, Jr., Clinica Campesina (MLK) in Homestead, Florida. The goal is to provide migrant workers and their families easy access to quality health care. It was determined that the first telemedicine connection should be with dermatologists, since it was the most urgently needed specialty. The first Teledermatology Clinic was evaluated in October 1993.

GEORGIA

Telemedicine Project, Telemedicine Center, Medical College of Georgia.
Medical College of Georgia, Augusta GA 30912-1655

Contact: Jay H. Sanders MD; - (706) 721-6616 (voice) - (706) 721-7270 (fax) - jsanders.telemed@mail.mcg.edu (e-mail)

Project Summary: This project will eventually incorporate 49 sites, including two mobile vans for the Department of Corrections.

Emory University Health Communication Project
Robert W. Woodruff Health Science Center, 1440 Clifton, Atlanta GA 30322

Contact: Jeffrey Dunbar; - (404) 727-8218 (voice)

jdunbar@unix.cc.emory.edu (e-mail)

Technologies: AT&T's Picasso

Vendors: AT&T

Project Summary: This project includes research and development on telemedical technology, particularly transmission of static images and audio with AT&T's Picasso system. The project is designing clinical trials now to test efficacy, particularly the physician and patient response to telemedicine.

The Center for Total Access

Department of the Army, Headquarters, Dwight David Eisenhower Army Medical Center, Fort Gordon, GA 30905-5650

Contact: Thomas E. Knuth, MD, MPH, Chief, Trauma & Surgical Critical Care, Director of Telemedicine; - (706) 787-1138, 7248, 5811 (voice) - (706) 787-4934 (fax) - tknuth@ftgordon-amedd.army.mil (e-mail)

System: Store and forward and interactive video

Applications: Dentistry, pathology, child psychiatry, dermatology, radiology, emergency medicine, combat/tactical telemedicine

Funding: Department of Defense, congressional appropriation

Project Summary: The Center for Total Access (CTA) is responsible for the Army's telemedicine initiatives in the southeast and is located at the Eisenhower Army Medical Center. The mission of the CTA is to facilitate health care delivery using advanced medical, communications, and information technologies so that all Army, Navy, and Air Force patients will have quick and convenient access to appropriate health care. The CTA has begun the deployment of telemedicine modules in its region in support of the most immediate identified needs, including dentistry, child psychiatry, pathology, dermatology and radiology. A Community Healthcare project is under way jointly with the CTA, the Medical College of Georgia and Georgia Institute of Technology to place home health care modules in selected homes in order to provide a "virtual presence" of health care providers within easy reach of these patients.

IDAHO

Boise State University, Center for Health Policy
1910 University Place, Boise ID 83725

Contact: Dr. Eldon Edmundson, Ph.D.; - (208) 385-1678 (voice) - (208) 385-3469 (fax) - eedmundson@bsu.idbsu.edu (e-mail)

System: Store and forward and interactive

Applications: Patient record sharing

Technologies: Personal computer, workstation, scanner

Funding: 50% NTIA grant, 50% local funds, total project \$272,568

Project Summary: The objective of this project is to develop a CHIN (Community Health Information Network) which will serve the Magic Valley region of southern Idaho and northern Nevada. The CHIN will integrate and automate the clinical functions of six hospitals, 200 physicians in their offices, public health and other ancillary health care professionals. Among services envisioned for the CHIN are electronic capture of patient encounter information, integration of the clinical information systems of all providers, expert system software to provide alerts and reminders to care providers, and incorporation of telemedicine technologies to serve remote, underserved areas.

ILLINOIS

Carle Center for Rural Health and Farm Safety, Rural Telemedicine Project
Project Visual Communications, Carle Foundation Hospital, 611 W. Park, Urbana, IL 61801

Contact: Fred Peralta; - (217) 383-3041 (voice) - (217) 303-3993 (fax)
fperalta@firefly.prairienet.org (e-mail)

System: Interactive

Applications: Oncology, cardiology, emergency medicine

Technologies: Videoconferencing; full T1 lines

Vendors: VTEL

Funding: State grants, in-kind services, phone company grant; \$100,000/yr

Project Summary: CARLE is exploring avenues to increase specialty coverage to medically underserved areas. The emergency medicine aspect of the project is presently the most exciting, connecting a small community emergency department to a level 1 trauma center. The small emergency department can then be staffed by a physicians assistant overnight, saving expenses and extending coverage. The system is collaborative with several diverse organizations.

IOWA

Midwest Rural Telemedicine Consortium (MRTC)
Mercy Hospital Medical Center, 400 University Avenue., Des Moines, IA 50314

Contact: Paul Maakestad, Project Director, Harrison Pratt II, D.O., Principal Investigator;
- 1-800-637-2994 ext. 8750 or (515) 247-3248 (voice) - (515) 243-5633 (fax)

System: Two-way interactive

Applications: Oncology, cardiology, dermatology, orthopedics, neurology, mental health

Funding: HCFA, \$3.5M

Project Summary: In 1992, Mercy Hospital Medical Center and Mercy Health Services, Iowa/Indiana Region, formed an alliance to strengthen the access avenue to rural Iowans. The partnership was awarded \$3.5M to study telemedicine as an additional method of providing health services. The three year study will analyze: the utility of telemedicine, safety and efficacy; acceptance of the technology; the cost-effectiveness; and if telemedicine provide better access to health care. The study will evaluate interactive video consultations by specialists and primary care physicians. Four of the eight participating hospitals will be linked in early 1995; the remaining four by the end of 1995.

Iowa Telemedicine Network; Iowa Methodist Medical Center
1200 Pleasant Street, Des Moines, IA 50309

Contact: Ginny Wagner, Director, Information Technology/Strategic Planning; - (515) 241-5998 (voice) - (515) 241-5160 (fax)

System: Interactive

Applications: Echocardiography, teleradiology, telepathology, emergency room, NICU, cardiology, pediatrics

Technologies: State-wide fiber optic cable; full-motion video

Funding: HCFA \$698,000; Blue Cross/Blue Shield Foundation, \$37,700

Project Summary: The Iowa Communications Network is a 2950 mile State- owned and operated continuous fiber optic network. There are 129 points-of-presence, connecting all 99 counties, through Part 2 completion of the network. They are currently involved in Part 3 expansion of the network which will extend an additional 350 sites across the State. All sites to date, with the exception of four hospital connections, are educational or State Government sites. Hospitals have been allowed access by the Iowa State Legislature. The HCFA grant will allow evaluation of the telecommunications medium for clinical applications of telemedicine, education, and information system applications. The project involves Iowa Methodist, Trinity Regional Hospital in Fort Dodge, and Greene County Medical Center in Jefferson.

National Laboratory for the Study of Rural Telemedicine
222 CMAB, University of Iowa, Iowa City, IA 52242

Contact: Michael G. Kienzle MD, Associate Dean, Clinical Affairs; - (319) 353-5637 (voice) - (319) 335-8318 (fax) - michael-kienzle@uiowa.edu (e-mail)

System: Store and forward and interactive

Applications: Resource Center, test bed of three rural hospitals; two information support projects; and three clinical support projects.

Funding: NLM grant of \$7.3M to study rural telemedicine

Project Summary: The NLM contract supports four developmental components: 1) a Resource Center, which will provide the administrative and technical support necessary to

complete the proposed work and to facilitate interactions with other telemedicine investigators on campus, statewide and eventually nationally; 2) a hospital test bed; 3) information support projects, which will provide enhanced electronic health sciences library services, including document delivery, to rural hospitals, and a Virtual Hospital, a digital multimedia database supporting access to information for practice and continuing education; and 4) clinical support projects, where two radiology-related projects will determine cost-effective protocols for interpretation of routine and subspecialty radiographs within a three-tier system of hospitals.

KANSAS

University of Kansas Medical Center
3901 Rainbow Blvd., Kansas City KS 66103

Contact: Chris Budig, Telemedicine Coordinator; - (913) 588-4295 (voice)

Project Summary: Ten sites performing clinical assessments, and 30 for education.

KAWNET, Community Hospital of Onaga, Incorporated
114 W. 8th Street, Onaga, KS 66521

Contact: Joe Engelken MPH, CEO; - (913) 889-4272 (voice) - (913) 889-7163 (fax)

System: Store and forward and interactive

Applications: Dermatology, pathology, radiology, cardiology, mental health, obstetrics-gynecology, orthopedics, pediatrics, trauma/emergency services; pulmonology, ENT, gastroenterology; rehabilitation medicine; allergy; occupational medicine; oncology; surgery; neurology; ophthalmology technologies: videoconferencing; teleradiology

Vendors: CLI

Funding: Rural Electrification Administration, \$500,000

Project Summary: This project is designed to develop and implement an integrated multihospital and clinic interactive telemedicine system that is defined and centered on the needs of the primary care physicians and hospitals using it. Grounded in twenty comprehensive clinical systems of patient care, the cooperative network is overseen by a Clinical Systems Team of primary care physicians supported by the range of subspecialty disciplines.

KENTUCKY

University of Kentucky School of Medicine
University of Kentucky School of Medicine, Kentucky Clinic South, 2400 Greatstone Point, Lexington, KY 40504-3274

Contact: Robert Schosser MD; - (606) 257-5727 (voice) - (606) 257-2447 (fax)

System: Store and forward and interactive

Applications: Dermatology, ophthalmology, mental health, emergency medicine, cardiology, dentistry, pathology, radiology, orthopedics

Technologies: Videoconferencing equipment linked via T1 lines and ATM; still image transfer at all sites with 486 PC; teleradiology and telepathology

Vendors: Under consideration: VTEL 127M and 227M video-conferencing equipment; Intel framegrabber board; FarSite software; Image Data teleradiology system; Roche telepathology system

Funding: Office of Rural Health Policy grant (\$1.5M) and Appalachian Regional Commission (ARC) grant (\$213,000)

Project Summary: The grants awarded will establish a telemedicine network in eastern Kentucky over a three-year period. The objectives are to investigate the feasibility, costs, appropriateness and acceptability of telemedicine consultations for improving access to health services for rural residents and reducing the isolation of rural practitioners. In year one two compressed-video systems will be installed in rural hospitals; still-image transfer systems will be installed in three other clinics. In years two and three the network will be expanded, as well as additional compressed-video sites; teleradiology and telepathology capabilities will be extended to additional sites; clinical services will expand to mental health. The primary task for year three will be a summary evaluation of the progress of the network.

University of Louisville

Room 320 MDR Building, 511 South Floyd Street, Louisville, KY 40292

Contact: Subhas C. Gupta MD, Research Assoc., Division of Plastic & Reconstructive Surgery; - (502) 852-1338 (voice)

scgupt01@ulkyvm.louisville.edu (e-mail)

Project Summary: Working with four physicians and the director of telecommunications, this project will cover all specialties, including dermatology. The project will start with urgent care. Two sites will be connected to the University Hospital emergency room. This system and the University of Kentucky system will run for one year. Kentucky is then scheduled to implement a statewide ATM network which will include the University of Louisville's telemedicine network. The project is also creating a series of "how-to" articles on setting up a telemedicine system.

MARYLAND

Department of Defense Telemedicine Testbed

US Army Medical Research and Matériel Command, Medical Advanced Technology Management Office, ATTN: MCMR-AT, Building 1054, Fort Detrick, Frederick MD 21702-5012

Contact: Jesse C. Edwards, Jr., Deputy Program Manager; - (301) 619-2468 (voice) (301) 619-2518 (fax) - edwards@ftdetrick-atmo1.army.mil (e-mail)

System: Store and forward and two-way interactive

Applications: All medical specialties

Technologies: Two-way and one-way video; two-way audio; distance learning utilization; videoconferencing

Funding: Internal

Project Summary: The Telemedicine Test Bed was established to manage rapidly advancing digital communications technologies with military medical applications. The test bed promotes rapid evolution and integration of telemedicine in the Military Health Services System infrastructure for improvements in medical outcomes. Military telemedicine will focus on the following: the evolving nature of military battlespace and military medical environment to support operational missions; developing total access for difficult, expensive, and underserved patients; use rapid prototyping and process re-engineering for development of new medical practice and advanced technology applications; have potential for measurable improvement of outcomes; be designed to achieve inter-operability, scalability, and upgradeability, and mandate active outreach and collaboration with academia, industry and other governmental agencies.

MASSACHUSETTS

Telemedicine Project in the Radiology Department

New England Medical Center, Cardiovascular & Interventional Radiology, 750 Washington Street, Boston, MA 02111

Contact: Neil J. Halin D.O., Coordinator
Neil.Halin@es.nemc.org (e-mail)

System: 2-way video

Applications: teleradiology

Technologies: interactive two-way television

Vendors: PictureTel PCs-100 desktop unit

Funding: In partnership with Medical Image Management Incorporated of Fall River.

Project Summary: This project implemented a full motion video digital-video capture and video-conferencing system based on PictureTel's PCS-100 desktop unit. Remote physicians share cardiac studies almost in real-time with New England Medical Center physicians.

MICHIGAN

Upper Peninsula Telemedicine Project

Marquette General Hospital, Education Department, 420 West Magnetic, Marquette, MI 49855

Contact: Telemedicine coordinator, or Sally Davis, Director of Education; (906) 225-3018 (voice) - (906) 225-3037 (fax)

System: Store and forward and interactive video

Applications: Tumor Board, chemotherapy administration, respiratory medicine, medical education

Technologies: One ISDN (2x64 kbps) line, video, teleradiology; scanners, personal computers

Vendors: PictureTel VTC 4000EX; ICON Medical Systems for teleradiology

Funding: Rural Utilities Service, and Health Resources and Services Administration grants, approximately \$2.5M.

Project Summary: This project is designed to establish an Upper Peninsula Telemedicine Project to serve the needs of rural residents of the Upper Peninsula of Michigan by providing electronic connections between Marquette General Regional Medical Facility in Marquette, and four rural communities. Emphasis on medical applications, with some education. Both video teleconferencing and teleradiology will be utilized to reduce isolation and increase access to specialized health care services for the rural population. The Upper Peninsula Rural Health Project will provide various components of data transfer, teleradiology and video teleconferencing to rural health clinics. This project builds on the Upper Peninsula Telemedicine Project by providing data transfer services to several remote rural clinics and increasing the number of sites with teleradiology and video teleconferencing.

MINNESOTA

Mayo Clinic

200 First Street SW, Rochester, MN 55905

Contact: Eric Tangelos MD or Marvin Mitchell (technical questions); - (507) 284-5126 - (507) 284-3986 (voice) - (507) 284-5073 (fax) eric_tangelos@msgw.mayo.edu (e-mail)

System: Satellite

Project Summary: Satellite technology links clinics in Rochester, Scottsdale AZ, and Jacksonville, FL. Used for education, research, administration and a full range of telemedicine applications.

MISSOURI

University of Missouri, School of Medicine

117 Old Alumni Center, DC 345.00, Columbia MO 65212

Contact: Joe Tracy, Director of Telemedicine; - (314) 882-7444 (voice) (314) 882-5666 (fax) - tracyj@ext.missouri.edu (e-mail)

System: Interactive video and store and forward

Applications: Teleradiology, cardiology, dermatology, mental health, obstetrics and gynecology, orthopedics, pediatrics, trauma and telepathology

Technologies: Interactive two-way television, personal computers

Vendors: VTEL, PCs

Funding: Office of Rural Health Policy - HRSA \$1.2M; MU Health Science Center and private money, approximately \$3.1 M.

Project Summary: This project is designed to demonstrate interactive two-way telemedicine consultations and collect information on the feasibility, appropriateness and acceptability of telemedicine consultations for improving access to health services for rural residents and reducing the isolation of rural practitioners. The project is also designed to provide medical education (CME) to rural physicians and/or allied health professionals.

MONTANA

Eastern Washington University Montana Telemedicine Network
Deaconess Medical Center, P.O. Box 37000, Billings, MT 59107

Contact: Thelma McClosky Armstrong; - (406) 657-4870 (voice) - (406) 657-4875 (fax)
- davida8328@aol.com (e-mail)

System: Store and forward and interactive video

Applications: Dermatology, psychiatry, radiology, neurology, orthopedics, pathology

Technologies: Interactive two-way video, phones

Vendors: VTEL BK227 interactive video unit with MCU II videobridge, Picasso phones

Funding: REA/ORHP

Project Summary: The network uses two-way interactive videoconferencing technology to deliver specialist medical and mental health care services, continuing medical and higher education, and community development initiatives in rural geographically isolated communities of eastern Montana. The urban provider and project hub is Deaconess-Billings Clinic Health system in Billings, and all Billings based specialist physicians.

NEBRASKA

Good Samaritan Hospital
P.O. Box 1810, Kearney, NE 68848-1810

Contact: Donna Hammack; (308) 236-7524 (voice)

Project Summary: The Mid-Nebraska Telemedicine Network encompasses a service area of eight counties in central NE covering 6500 square miles and a population of 45,000. Good Samaritan, a regional referral center, will provide specialty consultations to five rural hospitals and one rural clinic using interactive video.

Native American Public Broadcasting Consortium, Incorporated

1800 N. 33rd. Street, 309TC, Lincoln, NE 68583

Contact: Mr. Frank Blythe; - (402) 472-3522 (voice)

Funding: NTIA grant: \$155,844, total project cost \$311,688

Project Summary: To support planning to link over 500 Native American tribal governments nationwide, leading to a demonstration project. Ten sites will be analyzed for existing local infrastructure in ND, SD, CO, WY, NC, MI, CA, and OK. Six areas of tribal services will be examined: telemedicine, economic development, child care, education, cultural preservation, and government.

NEW YORK

New York State Department of Health

ESP, Wadsworth Center, Room C273, P.O. Box 509, Albany, NY 12201-0509

Contact: Donald F. Parsons MD; - (518) 474-7047 (voice) - (518) 7992 (fax) - dfp10@uacsc2.albany.edu (e-mail)

System: Workstations

Applications: Interhospital networking

Technologies: Sparc5 solaris 2.3

Vendors: SUN

Funding: New York State Department of Health, \$2500

Project Summary: This network moderates HSPNET-L@albnydh2.bitnet and originated the newsgroup, sci.med.telemedicine. These news groups serve as a resource for national and international medical networks. A monthly digest is stored on listserv@albnydh2 with some summary files.

NORTH CAROLINA

East Carolina School of Medicine

1S-10 Brody Building, Greenville, NC 27858-4354

Contact: David Balch MD; (919) 816-2466 (voice) - (919) 816-2310 (fax)
dave@sparky.med.ecu.edu (e-mail)

System: Store and forward and interactive

Applications: 15 medical disciplines; most usage in dermatology and neurology

Technologies: STS technologies over ATM for 9 sites; PC workstations over T1 for 3 sites; 9 site teleradiology system over ATM for 9 sites

Vendors: PictureTel 4000 running over microwave for 2 sites; CLI Rembrant III over T1 for 3 sites

Funding: Internal; HCFA, NTIA, ORHP, NC Information Highway

Project Summary: The ECU Telemedicine project began in 1991 with a link between ECU and Central Prison in Raleigh, 100 miles away. The prison link has proven to be cost effective in the delivery of specialty care. The same need for specialty care exists in medically under-served rural Eastern North Carolina. REACH-TV is a telecommunications network deployed to provide telemedicine and distance learning to these isolated populations in North Carolina. The goals of the network are to provide a medical communications system that will limit "drive time" for participants without the constraints of weather and geography, while providing ongoing professional training to health care professionals. The network is a hybrid utilizing fiber optics, conditioned copper and microwave links to provide two-way audio, video, and data capabilities to a geographical area larger than nine states. Over 300 medical consultations have been done over this network, involving 31 different physicians from 15 medical disciplines. The average time of a consultation is about 30 minutes. A computerized patient record has been implemented in the host medical center and will be extended electronically to all remote sites. A custom designed telemedicine suite has been constructed consisting of four 6'x12' video booths which provide monitors, graphics transmission, and touch screen controls of all equipment. This suite of rooms currently supports four simultaneous medical consultations to four different sites.

Carolinas Medical Center
P.O. Box 32861, Charlotte, NC 28232

Contact: Richard Peindl Ph.D., Director, Orthopedic Engineering Research; (704) 355-7084 (voice) - (704) 355-4238 (fax) - peindl@uncc.edu (e-mail)

System: Store and forward and interactive video

Applications: Cardiovascular surgery, orthopedics and dermatology

Technologies: Personal computers

Vendors: Apple (Macs)

Funding: Department of Defense, \$3M

Project Summary: Analog/digital medicine is involved with developing telemedicine applications for use both on a digital network and a parallel analog network (PAN). One of the main goals of the project is to determine to what extent analog video can be utilized to offload the digital network. The project involves Carolina Medical Center, Walter Reed Army Medical Center, and satellite hospitals affiliated with the two institutions.

North Carolina Health Care Information and Communications Alliance, Incorporated
116 W. Jones Street, Room. 5050, Raleigh, NC 27603-8003

Contact: Sheron K. Morgan Ph.D., President and CEO; - (919) 733-4131 (voice) - (919) 715-3562 (fax) - G1SP001@ospl1.ospl.state.nc.us (e-mail)

System: Interactive video

Applications: Emergency medicine, radiology, general medicine

Technologies: ATM/SONET full motion video, NCREN videoconferencing, telephone/fax, microwave-based, total bandwidth in T1 range

Vendors: Local carriers, NCREN

Funding: NTIA/State of NC Grant: \$1,050,000, plus \$4M in kind

Project Summary: The primary goals of this project are to demonstrate systems in which telemedicine improves the quality of health care available to rural and otherwise disadvantaged residents, and to improve the viability of rural hospitals which assure rural residents access to care. The State of NC proposes to link emergency departments at each of the state's four medical centers affiliated with medical schools (Bowman Gray, Duke University, East Carolina University, University of North Carolina) with five remote site hospital emergency departments including one military base hospital emergency dept., to provide teleconsultations (including general trauma consults, as well as teleradiology consults) during emergencies. The project will utilize the broadband, ATM/SONET-based NC Information Highway to connect the sites.

OHIO

Cleveland Clinic

9500 Euclid Avenue, Cleveland, OH 44195

Contact: Philip Bailin MD, Chair, Dermatology

Applications: Dermatology, ophthalmology, echocardiography and teleradiology

Project Summary: During the period April through May of 1994, teleconferencing equipment was tested using medical instruments at a distance for consultation and grand rounds, and to gauge physician and patient acceptance. The results of the trial were positive, so the foundation purchased telemedicine systems for its three locations. The foundation also plans to set up links with affiliated hospitals and to hospitals in the Middle East.

OKLAHOMA

Center for Telemedicine, University of Oklahoma Health Sciences Center

1000 Stanton L. Young, Room 221, P.O. Box 26901, Oklahoma City, OK 73190

Contact: Gene Hopper; - (405) 271-2332 (voice) - 271-2332 (fax)

Applications: Radiology, ophthalmology, tele-education and tele-administration

Project Summary: This project links rural physicians and medical specialists at Oklahoma University Health Science Center. Two sites are currently using teleradiology, and one site is using tele-ophthalmology. The project also currently incorporates tele-education and tele-administration. This project will also provide access to online information available at the medical library including Medline and CE programs. OUHSC is also assisting in the development of the Oklahoma Telemedicine Network, an open statewide system supporting participation of 39 hospitals and 20 privately funded hospitals.

Department of Ophthalmology and Center for Telemedicine, University of Oklahoma Health Sciences Center
Dean A. McGee Eye Institute, 608 Stanton L. Young Boulevard, Oklahoma City, OK 73104

Contact: Stephen Fransen MD, Assistant Professor; - (405) 271-7521 (voice) - (405) 271-8781 (fax) - stephen-fransen@uokhsc.edu (e-mail)

System: Store and forward

Applications: Diabetic retinopathy screening

Technologies: DCS100 digital camera; Power Macintosh

Vendors: Kodak; and Apple

Funding: State of Oklahoma, Sarkeys Foundation, CDC; \$450,000

Project Summary: This project is developing general purpose telemedicine software that initially is focused on the vertical implementation of high performance diabetic retinopathy screening. The goals of the project include the ability to provide primary screening for the presence of diabetic retinopathy with high sensitivity and specificity as well as more sophisticated diagnosis of clinically significant parameters which lead to treatment decisions.

Comanche County Memorial Hospital
3401 West Gore Boulevard, Lawton, OK 73505

Contact: Mr. Rick Calonsil; - (405) 355-8699 ext. 3082 (voice) - (405) 585-5457 (fax)

System: Interactive video and store and forward

Applications: Cardiology, continuing medical education, diabetes education

Technologies: PC, scanner, teleradiology, video, T1 communication lines

Funding: NTIA, \$496,000

Project Summary: This project is designed to establish a telemedicine network in southwest Oklahoma. Interactive video telemedicine workstations and other equipment will be purchased for First Health West, a hospital and physician network that includes CCMG and eight rural hospitals. One of the primary uses will be interactive clinical consultations, in which primary care physicians in rural areas consult by video with specialists at CCMH, a 283 bed regional referral center. They will use T1 lines which have been fractionated (divided) into 24 separate channels. All clinical and management information will be sent via separate channels over one T1 line. The entire project will be up in 18 months; the interactive clinical consultations between CCMH and the rural FHW hospitals could be operational by mid-1995

OREGON

Advanced Telemedicine Research Group
Biomedical Information and Communication Center, Oregon Health Sciences University, Portland, OR 97201-3098

Contact: Douglas A. Perednia, MD; - (503) 494-6846 (voice) - 494-4551 (fax) - perednia@ohsu.edu (e-mail)

Applications: Dermatology

Funding: National Library of Medicine HPCC contract, \$1.9M

Project Summary: This project is providing basic research into the specification and design of an economical and useful teledermatology system. Factors to be studied include the spatial and color resolutions required, the application of image compression schemes made practical by use of high-speed computing; equipment needed to produce acceptable results over a wide area network; and protocols for skin image transmission and storage for clinical or research use. Three rural sites in Oregon have been chosen to participate.

PENNSYLVANIA

Saint Francis College, Center of Excellence for Remote and Medically Under-Served Areas (CERMUSA)

Stokes Building, Room 232, Loretto, PA 19540

Contact: Ken Harbert, Project Director; - (814) 472-3387 (voice) - (814) 472-3389 (fax)

Applications: Training, education, and telemedicine

Funding: Research grant from the Navy Health Sciences Education and Training Command

Project Summary: CERMUSA's mission is to identify the best practices in remote training, education, and telemedicine. Conducts research projects and disseminates findings. For telemedicine, a team focuses on research and projects related to the integration of technology in the delivery of health care to remote and/or medically under-served areas. In the first year, CERMUSA is addressing provider isolation and improved remote education.

SOUTH DAKOTA

State of South Dakota Office of Health Policy & Planning.

445 E. Capitol, Pierre, SD 57501

Contact: Patty Lihs, Telemedicine Coordinator; - (605) 773-3361 (voice) (605) 773-5683 (fax) - pattyli@doh.state.sd.us (e-mail)

System: Store and forward and interactive

Applications: Radiology, cardiology, dermatology, obstetrics, mental health, oncology, pulmonology and pathology

Technologies: Teleradiology

Vendors: ICON and Kodak for teleradiology, Micromedical for SAF cardiology

Funding: Community Development Block Grant for \$500,000, Federal Office of Rural Health Policy grant for \$460,680 year one.

Project Summary: The three largest hospitals in South Dakota, Sioux Valley Hospital, McKennan Hospital and Rapid City Regional Hospital, have formed a consortium for pursuing telemedicine technology on a coordinated, cooperative basis. They hope to form a network of three multi-specialty tertiary care hub site hospitals providing 24-hour day specialty consultation; establish rural sites to interact with the hub sites; to provide training for emergency medical services personnel, residents and other health professions students; and conduct an evaluation of telemedicine user acceptance, effectiveness, utilization, cost-effectiveness and technical capacity and reliability, and finally, establish criteria for the selection of future telemedicine rural sites.

TEXAS

Texas Telemedicine Project

TICS/MCC, P.O. Box 200195 Austin TX 78759

Contact: Jane Preston MD; - (512) 477-9119 (voice) - (512) 477-9099 (fax)
21754.2763@cls.com (e-mail)

System: Store and forward and interactive

Applications: All specialties

Technologies: Videoconferencing

Vendors: VTEL CODEC on VTEL CS350 based system with 20" monitors at each site, zoom camera, microphones, PCs and VCRs

Funding: Meadows Foundation and in-kind contributions from GTE, LODS and Southwest Bell among others

Project Summary: The equipment is at seven sites: four in Austin, and three in the rural community of Giddings. The objectives are to design and replicate a telemedicine delivery system for economies of scale in a rural community, and to study the viability factor using costs, savings and revenue as indices of viability barriers and support.

Telemedicine Program Office, Department of Medical Informatics, The University of Texas Medical Branch

Telemedicine Program Office, Department of Medical Informatics, University of Texas Medical Branch, Galveston, TX 77555-0840

Contact: Robert M. Brecht, Ph.D.; - (409) 747-0724 (voice) - (409) 747-0723 (fax) - rmb%utmbgalv@mhost.utmb.edu (e-mail)

System: Store and forward and interactive

Applications: General surgery, orthopedics, infectious diseases, hematology, rheumatology, urology, ophthalmology, vascular surgery, general medicine, pulmonary medicine, dermatology neurology, cardiology

Technologies: Videoconferencing; otoscope, ophthalmoscope, digital stethoscope

Vendors: CLI Radiance videoconferencing integrated through AccessMed software; Sony patient camera

Funding: Texas Department of Managed Care Plan; institutional funds; \$625,000 for current fiscal year

Project Summary: The University of Texas Medical Branch is phasing in telemedicine as part of its managed care contract with the Texas Department of Criminal Justice. Phase one utilizes four different implementation models to determine appropriate technology, types of patients, prisons by type and size, measures cost effectiveness, support systems required, appropriate presenters, and other applications. The project currently sees 35-50 patients per week and expects to double that number by September of 1995. Seventeen different telemedicine specialty clinics are scheduled, the frequency of which relates to the number of referrals made to that particular clinic. The project is managed by a project director who reports to the Associate Medical Director for Information Systems and Telemedicine for the Managed Care Office.

University of Texas Medical Branch (UTMB)
301 University Boulevard, Galveston, TX 77555-0783

Contact: E. Ben Smith MD or Cathy Newman MD; - (409) 772-1911 (voice) (409) 771-1943 (fax)

System: Store and forward and interactive

Applications: Dermatology

Funding: Texas Dept. of Criminal Justice; NASA

Project Summary: This initiative Involves two projects: 1) phasing-in telemedicine as part of the managed care contract with the Texas Department of Criminal Justice, and 2) helping NASA and the UTMB Department of Family Medicine develop telemedicine for possible use in space and/or rural areas.

UTAH

University of Utah

Division of Dermatology, Room 4B454, University of Utah School of Medicine, 50 North Medical Drive, Salt Lake City, UT 84132

Contact: Marta Petersen MD; - (801) 581-7837 (voice) - (801) 581-6484 (fax) - mpetersen@msscc.med.utah.edu (e-mail)

System: Interactive video

Applications: Teleradiology, dermatology, pediatrics, mental health, obstetrics and gynecology

Technologies: videoconferencing; x-ray scanner, dedicated T1 line, broad band radio

Vendors: VTEL

Funding: Internal

Project Summary: This project is designed to provide teleradiology services to the Wendover, Nevada clinic (owned and operated by the University of Utah) as well as clinical telemedicine services via two-way interactive video for dermatology, pediatrics, mental health and obstetrics and gynecology. The project start date is June 1995.

VERMONT

**Department of Pathology, Fletcher Allen Health Care
Burlington, VT 05405**

Contact: Kevin Lescie, M.D., Director of Anatomic Pathology; - (802) 656-2798 (voice)
- (802) 656-3509 (fax) - kleslie@moose.uvm.edu (e-mail)

System: Interactive video

Applications: Telepathology, dialysis, clinical conference/continuing medical education (CME)

Technologies: Videoconferencing

Vendors: VTEL Media Max

Funding: Institutional; \$250,000

Project Summary: This project supports three connected hospitals. The primary function is pathologist-to-pathologist telepathology consultation. The project's objective is to provide a comprehensive telemedicine system within three years, beginning with billable services (pathology and radiology consultation) and continuing medical education (CME).

WASHINGTON

**University of Washington
School of Medicine, Box 355304, Department of Family Medicine, Seattle, WA 98195**

Contact: Peter West MD; - (206) 685-3676 (voice) - (206) 543-8911 (fax) -
mancare@u.washington.edu (e-mail)

System: Store and forward and interactive

Applications: Teleradiology, cardiology, dermatology, emergency medicine/trauma, mental health, obstetrics and gynecology, orthopedics, pediatrics and neurosurgery

Technologies: Using 486 PC desk-top computers with imaging software; digital scanner for transfer of still images

Vendors: Not determined as of February 1995

Funding: Office of Rural Health Policy, \$499,993/year for three years

Project Summary: The Washington, Alaska, Montana, and Idaho (WAMI) Rural Telemedicine Network is a three year demonstration project. The project's primary purpose is to explore the utility of telemedicine consultation provided by a tertiary care medical school facility to clinicians and patients of four remote towns in Washington, Alaska, Montana and Idaho. Consultations will take place at each of the remote sites and near the

emergency rooms of the University of Washington Medical Center and Harbor View Medical Center with a planning process underway for space at Children's Hospital and Medical Center. Consultations will initially be available on a scheduled basis. Emergent consultations will be implemented as the project develops. The consults will be professional to professional and may include the patient. The project directors are also working with the Health Care Financing Administration to develop strategies for reimbursement and hope to build a reimbursement demonstration in the project.

Yakima Valley Radiology (YVR)
314BS, 11th Avenue, Yakima, WA 98902-2925

Contact: David Zulauf MD; - (509) 248-7380 (voice)

Applications: Radiology

Technologies: T1 lines

Funding: Internal; not a grant-funded system

Project Summary: This is a regional wide-area telemedicine/teleradiology system. It integrates limited amounts of on-site care using T1 lines and imaging/video conferencing equipment. The system provides radiology services to small rural and urban clinics. YVR has a CLI unit with approximately 95% resolution. The network includes six hospitals in 5 cities plus an outpatient imaging center. The group is performing a variety of applications, including primary MR interpretation, CT, ultrasound, and telefluoroscopy.

Project Seahawk
Madigan Army Medical Center, Tacoma, WA 98431-5000

Contact: Richard G. Kirchdoerfer MD, Chief, Informatics; - (206) 968-3276 (voice) - 968-0365 (fax) - RKIRCH@tacoma-AMEDD.Army.MIL (e-mail)

Technologies: Teleradiology

Vendors: Teleradiology: Loral Medical Imaging Systems, 3200 Zanker Rd., P.O. Box 49041, San Jose, CA 95161-9041

Communications: US West.

Project Summary: The Project Seahawk objective is to provide telemedicine (including teleradiology) capability to federal medical treatment facilities in the Puget Sound region. The teleradiology portion is headed by Dr. Greg Bender and will use the medical diagnostic imaging support system (Loral). Dr. Sid Sado heads the development and implementation of the telemedicine applications other than teleradiology.

WASHINGTON, DISTRICT OF COLUMBIA

National Aeronautics and Space Administration (NASA)
(NASA) Headquarters, Code UO, 300 E Street SW, DC 20546

Contact: Charles Doarn or Robert Krause; - (202) 358-0821 or (202) 358-4538 (voice) - (202) 358-3038 (fax) - cdoarn@gm.olmsa.hq.nasa.gov or rkrause@gm.olmsa.hq.nasa.gov (e-mail)

System: Store and forward and interactive video

Funding: Funding is provided from the budget for the human space flight program

Project Summary: Telemedicine is incorporated into the delivery of medical care to astronauts. NASA has also worked with other National and International organizations using telemedicine for disaster response.

WEST VIRGINIA

Mountaineer Doctor TeleVision (MDTV)

Robert C. Byrd Health Sciences Center of West Virginia University, P.O. Box 9080, Morgantown, WV 26506-9080

Contact: John Turner, Program Director, James E. Brick MD, Medical Director; - (304) 293-4891 (voice) - jturner@wvupsi1.hsc.wvu.edu (e-mail)

System: Interactive, true full-motion (no frame doubling)

Technologies: Fully dedicated T1 network, video

Vendors: CLI Rembrant IIVP CODECs and CLI Multipoint Control Units

Funding: Federal and foundation grants with additional support from the WVU School of Medicine and the Charleston Area Medical Center

Project Summary: MDTV is West Virginia's statewide telemedicine network which connects rural hospitals to the state's Academic Medical Centers. Rural patients and providers are provided with real-time access to clinical, education and informational resources for medical consultations, educational opportunities and other clinical services. MDTV's goals are to enhance the level of care available at the community level and reduce the sense of professional isolation commonly experienced by rural health care providers. Clinical consultations with all specialties and sub-specialties; ancillary services established on a site by site basis. Fully automated switching and routing virtually eliminates the reliance on technical staff for clinical consultations.

APPENDIX C. TELEMEDICINE EQUIPMENT, SUPPLIERS, AND PRODUCTS

Telemedicine systems may be assembled utilizing commercial "off-the-shelf" business teleconferencing equipment and by adapting available medical peripherals. A number of vendors also specialize in specific telemedicine products and value-added services. The following is a list of vendors that have been involved in recent telemedicine projects. This listing is not comprehensive, however, it includes vendors that have been cited in literature, active at telemedicine conferences, and identified by telemedicine specialists.

Telemedicine System Manufacturers and Integrators

Compression Labs Incorporated (CLI)

Russ Liggett
2860 Junction Avenue
San Jose, CA 95134
314-542-3053

Manufacturer of interactive audio/video/data teleconferencing equipment. CLI has teleconferencing equipment available that has been successfully adapted for telemedicine applications. CLI telemedicine systems support multiple medical peripheral inputs.

PictureTel

Stephan Johnson
222 Rosewood Drive
Danvers, MA 01923
800-716-6000

Leading manufacturer of business teleconferencing equipment, which has models available that have been successfully adapted for telemedicine applications.

VTEL

Rebecca Whitehead
108 Wild Basid Road
Austin, TX 78746
512-314-2660

Manufacturer of interactive audio/video/data teleconferencing equipment, which has models available that have been successfully adapted for telemedicine applications. VTEL also manufactures cameras and other peripheral devices.

Hughes Medical Tele-Imaging

Morgan McCune
P.O. Box 92919
Los Angeles, CA 90009
310-364-6365
(Fax) 310-364-6076

Hughes produces integrated telemedicine systems, as well as networked systems for acquisition and transfer of patient data records and medical images.

DeBakey / Raytheon / ITS

William Stevens
24 Terry Avenue
Burlington, MA 01803
617-221-8058
(Fax) 617-221-8110

DeBakey / Raytheon / ITS produces an integrated telemedicine system called Medtel, which is the result of a joint venture of the three medical, technical, and telemedical firms.

NYNEX Media Communications Services

4 West Red Oak Lane
White Plains, NY 10606
914-644-7971

Medical Televideo Incorporated (MTI)

Rod McArthur
2452 Centerline Drive
Maryland Heights, MO 63043

MTI is a telemedical systems integrator that specializes in telepathology, telecardiology, and diagnostic instrumentation.

Swiderski Electronics Incorporated

Joseph M. Swiderski III
1200 Greenleaf Avenue
Elk Grove Village, IL 60008-5597
708-364-5019

Swiderski is a multidisciplined system integrator and value added reseller that specializes in the design, engineering and installation of a broad range of audio, video, data, and multimedia applications.

United Medical Network

Valeria Oravetz
708 South Third Street, Suite 400
Minneapolis, MN 55415

800-448-6679

612-330-0990

(Fax) 612-330-0989

United Medical Network is a telemedicine services integrator, which also provides dial-up telecommunications infrastructure services specifically for health care applications.

Telemedicine Equipment and Peripheral Providers

Andries Tek

Rondald Williams

4314 Medical Parkway

Austin, TX 78756

512-453-6076

(Fax) 512-453-8627

Andries Tek designs, manufactures or supplies a comprehensive variety of medical peripheral equipment (i.e., electronic stethoscopes, skin cameras, dopplers, endoscopic camera adapters, etc.), which is compatible with many of the leading manufacturers' teleconferencing and telemedicine systems.

Video Dynamics Incorporated (VDI)

Wayne Byard

13790 NW 4th Street

Suite 112

Sunrise, FL 33325

305-846-1490

(Fax) 305-846-1949

VDI manufactures a wide variety of medical peripheral equipment including micro-soakable cameras, ENT equipment, light sources, as well as other telemedical peripheral equipment.

Elmo Manufacturing Company

70 New Hyde Park Road

New Hyde Park, NY 11040

516-775-3200

Elmo manufactures a widely used desktop visual presenter for displaying documents, low-resolution radiographs, and objects.

Canon USA

One Cannon Plaza

Lake Success, NY 11042

516-328-5960

(Fax) 516-328-5959

Cannon manufactures still video cameras, video visualizers, and PC-based image digitizers, which may be adapted for use in telemedicine systems.

AMX Corporation

11995 Foretgate Drive

Dallas, TX 75243

800-222-0193

214-644-3048

(Fax) 214-907-2053

AMX manufactures icon driven touch screen controllers that have been optimized for telemedicine applications.

Heraeus Surgical Incorporated

575 Cottonwood Drive

Milpitas, CA 95035

408-954-4000

(Fax) 408-954-4040

Heraeus markets interactive surgical video systems that provide an integrated video network for use in monitoring, consulting, teaching, teleconferencing, and documenting of surgical procedures and surgical pathology.

Stryker Endoscopy

Frances Roche

210 Baypointe Parkway

San Jose, CA 95134

408-435-0220

(Fax) 408-435-1888

Stryker manufactures integrated endoscopic surgical suites that centralize control of all video functions within a surgical suite.

Corabi Limited

Mark Neuberger

890 South Pickett Street

Alexandria, VA 22304

703-823-4753

(Fax) 703-823-2584

Corabi manufactures telerobotic pathology workstations that allow remote visualization and manipulation of laboratory microscopes and peripheral equipment.

AT&T

Lisa Grote

15 West 6th Street, 3rd Floor

Cincinnati, OH 45202
800-245-0266 Extension 5911
(Fax) 800-289-0026

AT&T still-image picture phones can send still images over ordinary analog phone lines. Image sources may be camcorders, document scanners, photo CDs, as well as a host of other devices.

ScottCare

Mary Hall
115 B West Ticonderoga
Westville, OH 43081
800-308-3148
216-362-0550
(Fax) 362-6162

ScottCare has developed an integrated medical telemetry system for cardiac rehabilitation applications, which may be used by patients at remote locations under the supervision of a nurse at a central location.

InVision Systems Incorporated

Dave Gersh
703-506-0094
(Fax) 703-506-0098
(Fax) 703-506-0098

InVision is a leading developer of protocol-independent desktop conferencing systems.

APPENDIX D. TELEMEDICINE PERIPHERAL INPUT DEVICES

General Purpose Devices	Price Ranges*
Plain-paper fax machine	\$750 - \$1,500
Flat-bed page scanner	750 - 5,000
Radiographic film scanner	18,000 - 75,000
Digital Frame Grabber	2,000 - 3,000
Video Visualizer / Presenter	5,000 - 7,000
Digitizing Graphics Tablet	7,000 - 8,000
CCD Camera	5,000 - 15,000
Camera and Adapters for:	
Otosopes	6,500 - 10,000
Ophthalmoscopes	6,500 - 10,000
Flexible Endoscopes	6,500 - 10,000
Electronic Stethoscopes	4,000 - 8,000
Hand-Held Still-Image Camera	4,000 - 6,000
 Specialty Devices	
ECG machine with modem or communications ports	6,000 - 14,000
ECG and EEG transmission devices	500 - 5,000
Pathology microscope camera	6,000 - 8,000
Remote-controlled pathology microscope system	90,000 - 110,000
Dermatology skin camera (Dermascope)	3,000 - 10,000

* Prices may vary widely depending on features, specifications and options. Some peripherals require the use of a personal for interfacing, which is not included in these prices.

Information from Berek and Canna, 1994, p. 20.

APPENDIX E. NAVAL HOSPITAL CAMP PENDLETON TELEMEDICINE DEMONSTRATION PROJECT PATIENT LOG

[illegible]

CODES: AC = ACUITY CODES: U = URGENT, N= NON-URGENT

SE = SERIOUSNESS CODES: MA = MAJOR, D = DIFFERENTIAL, MI = MINOR

APPENDIX F. PATIENT SATISFACTION SURVEY

PATIENT SATISFACTION SURVEY
NAVAL HOSPITAL
CAMP PENDLETON, CALIFORNIA 92055-5008

SATISFACTION SURVEY FOR TELEMEDICINE DEMONSTRATION PROJECT

RANK/RATE: _____

PLEASE CIRCLE THE NUMBER THAT MOST CLOSELY CORRESPONDS TO YOUR OPINION:

STRONGLY DISAGREE - 1, DISAGREE - 2, NEUTRAL - 3, AGREE - 4, STRONGLY AGREE - 5

- | | |
|--|-----------|
| 1. THE STAFF PROJECTED A CARING ATTITUDE AND SEEMED WILLING TO HELP IN ANY WAY THEY COULD. | 1 2 3 4 5 |
| 2. THE LENGTH OF TIME IT TOOK TO BE SEEN WAS REASONABLE.
(HOW LONG DID YOU WAIT? _____) | 1 2 3 4 5 |
| 3. MY DOCTOR TOOK TIME TO ANSWER MY QUESTIONS. | 1 2 3 4 5 |
| 4. I FELT COMFORTABLE SEEING THE DOCTOR OVER TELEVISION. | 1 2 3 4 5 |
| 5. I FELT THAT THE TELEVISION SYSTEM WAS AS GOOD AS SEEING THE DOCTOR IN PERSON. | 1 2 3 4 5 |
| 6. I FELT THAT THE TELEVISION SYSTEM PROVIDED A GOOD UNDERSTANDING OF MY MEDICAL PROBLEM FOR THE DOCTOR. | 1 2 3 4 5 |
| 7. OVERALL, I WAS SATISFIED WITH THE CARE. | 1 2 3 4 5 |
| 8. I WOULD CHOOSE TO SEE THE DOCTOR OVER TELEVISION IN THE FUTURE. | 1 2 3 4 5 |

YOUR COMMENTS PLEASE: _____

APPENDIX G. TELEMEDICINE SYSTEM EVALUATION SURVEY

OPTIONAL: (Name: _____ Rate/Rank: _____ Position: _____)

1. Please indicate your primary function:

1. Referring physician
2. Consulting physician
3. Marine Corps staff recommending patients for the telemedicine project
4. Trainer providing classes
5. Other (Describe) _____

2. I have used the telemedicine system

1. One time (this is my first time)
2. Two times
3. Three times
4. Four times
5. More than four times

3. Were you formally trained on the use of the equipment?

1. Yes
2. No

4. If you were not formally trained, did you find the equipment easy to use?

1. Yes
2. No

5. The sound quality was

1. Excellent
2. Good
3. Poor
4. No Comment/ Not used

6. The clarity of the picture was

1. Excellent
2. Good
3. Poor
4. No Comment/ Not used

7. Your ability to identify participants was

1. Excellent
2. Good

3. Poor
4. No Comment/ Not used
8. The ease of use of the control panel was
 1. Excellent
 2. Good
 3. Poor
 4. No Comment/ Not used
9. The ease of use of camera controls (pan, zoom) was
 1. Excellent
 2. Good
 3. Poor
 4. No Comment/ Not used
10. Your ability to identify who was speaking (far end) was
 1. Excellent
 2. Good
 3. Poor
 4. No Comment/ Not used
11. The quality of moving images (far end) was
 1. Excellent
 2. Good
 3. Poor
 4. No Comment/ Not used
12. The clarity of still camera graphics was
 1. Excellent
 2. Good
 3. Poor
 4. No Comment/ Not used
13. The ease of use of the graphics camera and ability to transmit graphics was
 1. Excellent
 2. Good
 3. Poor
 4. No Comment/ Not used
14. As you see it, what are the primary benefits of the telemedicine system (check as many as necessary)
 1. Improved interaction

2. No benefit
 3. More effective communication and decision making
 4. Cost and time savings
 5. More people brought into the loop
 6. Other_____
15. Regarding your interaction with the telemedicine system, would you say that
1. The telemedicine system significantly shortened the length of the patient encounter and saved a considerable amount of my time
 2. The telemedicine system slightly shortened the length of the patient encounter and saved a small amount of my time
 3. The telemedicine system neither shortened nor lengthened the patient encounter and I worked at my usual pace
 4. The telemedicine system slightly extended the length of the patient encounter and required slightly more of my time
 5. The telemedicine system considerable lengthened the patient encounter and required much more of my time
16. What are the primary drawbacks to the telemedicine system?
1. Equipment problems
 2. Perceived loss of privacy
 3. Lack of training or familiarity with equipment
 4. Other_____
17. What is your overall impression of patient dispositions via telediagnosis?
1. Satisfactory
 2. Minor reservations
 3. Major reservations
 4. Not satisfactory
18. Is your overall impression of the telemedicine system
1. Positive
 2. Neutral
 3. Negative
19. Do you have any other comments about the telemedicine concept, capabilities, training, ease of use, etc.?

Thank you for your participation !

**APPENDIX H. TELEMEDICINE PILOT PROJECT PATIENT SATISFACTION
SURVEY RESULTS**

Survey	QUEST	QUEST	QUEST	QUEST	QUEST	QUEST	QUEST	QUEST	
#	# 1	# 2	# 3	# 4	# 5	# 6	# 7	# 8	AVG
	Score	Score	Score	Score	Score	Score	Score	Score	Score
1	4	4	4	4	5	4	4	4	4.1
2	4	3	4	5	3	4	5	5	4.1
3	5	5	5	4	4	4	5	5	4.6
4	5	5	5	4	3	3	4	5	4.3
5	3	2	3	1	1	1	1	1	1.6
6	3	4	4	5	5	4	4	4	4.1
7	5	4	5	5	5	4	4	5	4.6
8	4	5	5	4	5	5	4	5	4.6
9	5	4	5	4	5	5	5	5	4.8
10	5	4	5	4	4	5	5	5	4.6
11	4	4	5	5	5	5	5	4	4.6
12	3	5	5	5	5	4	5	5	4.6
13	4	5	4	5	5	4	5	5	4.6
14	5	4	4	5	5	5	5	5	4.8
15	5	4	5	4	5	5	5	5	4.8
16	5	4	5	5	5	4	5	5	4.8
17	3	5	5	4	5	5	5	5	4.6
18	4	5	5	5	4	5	4	5	4.6
19	5	5	5	5	5	5	5	5	5.0
20	5	4	5	5	3	5	5	5	4.6
21	4	3	5	4	4	4	4	3	3.9
22	5	4	4	5	5	5	5	5	4.8
23	5	5	5	5	5	5	5	5	5.0
24	4	5	4	4	5	4	5	5	4.5

25	5	4	4	5	5	4	4	5	4.5
26	4	4	5	5	4	4	5	4	4.4
27	5	4	4	5	5	4	5	5	4.6
28	5	4	5	5	4	4	5	4	4.5
29	4	5	4	5	5	4	5	5	4.6
30	4	5	4	5	5	5	4	5	4.6
31	4	5	4	5	5	4	5	5	4.6
32	5	4	5	5	4	5	5	5	4.8
33	5	4	5	5	5	5	4	5	4.8
34	4	5	5	5	4	5	5	5	4.8
35	4	4	5	5	5	5	5	4	4.6
36	5	5	4	5	5	5	4	5	4.8
37	4	4	3	5	5	3	5	5	4.3
38	4	5	4	5	5	5	5	5	4.8
39	5	4	5	5	5	4	5	5	4.8
40	4	3	4			4	5	5	4.2
41	4	3	4			4	5	5	4.2
42	4	3	4			4	5	5	4.2
AVG									
Quest									
Score	4.4	4.2	4.5	4.6	4.5	4.3	4.6	4.7	

LIST OF REFERENCES

- A.D. Little, Inc., *Telecommunications: Can it Help Solve America's Health Care Problems?* Arthur D. Little, Incorporated, Acorn Park, Cambridge, Massachusetts, Reference 91810-98, July 1992.
- Allen, A., "Patient-Physician Consultations Via Interactive Video in 1993," *The Telemedicine Newsletter*, 1(4), pp. 1,3, 1993.
- Allen, A. and Allen, D., "Telemental Health Services Today," *Telemedicine Today*, 2(1), pp. 12-15, 24, 1994.
- Allen, A., "American Telemedicine in the 1990's," *Telemedicine Today*, 3(2), pp. 1-5, February 2, 1995.
- Allen, A. "The Worldwide Web: An Application for the Health Professional," *Telemedicine Today*, 3(1), p. 23, 1995.
- Bashshur, R.L., ed., *Telemedicine: Explorations in the Use of Telecommunications in Health Care*, Springfield, IL: Thomas, 1975.
- Bashshur, R.L., "Telemedicine Effects: Cost, Quality and Access," Position paper for presentation and discussion at the Second National Aeronautics and Space Administration/Uniformed Services University of the Health Sciences International Conference on Telemedicine, Bethesda, Maryland, pp. 1-21, September 8-10, 1994.
- Baxter, C.F. et al., "After Action Report: Telemedicine Aspects of Challenge Athena," USS George Washington CVN 73 Medical Department, 1994.
- Berek, B., and Canna, M., "Telemedicine on the Move: Health Care Heads Down the Information Superhighway," *American Hospital Association, Hospital Technology Series (ISSN 0888-711X)*, 11(4), pp. 1-65, April 1994.
- Churchwell, W.M., *Videoconferencing and its Role in the Army*, Master's Thesis, Naval Postgraduate School, Monterey, California, June, 1994.
- Edwards, J., "Draft Telemedicine Test Bed (TTB) Management Plan," Medical Advanced Technology Management Office, Fort Detrick, Maryland, pp. 1-3, 16 December 1994.
- Freeman, M., "Standards for Telemedicine: Boon? Or Boondoggle?" *Healthcare Informatics*, 10(11): pp. 16-17, 19, 21, November 1993.

Hostetler, S., "Modern Medicine," *LAN Magazine*, 9(4):pp. 125-132, April 1994.

Inglis, A.F., *Electronic Communications Handbook*, McGraw-Hill, Inc., 1988.

Krajewski, M., "Medical Defense Performance Review Video Teleconferencing Test and Evaluation Plan," Mitre Corporation, Draft Version 3.0, November 1994.

Labriola, D., "Desktop Videoconferencing Candid Camera," *PC Magazine*, 14(8), pp. 221-254, April 25, 1995.

McGarty, T.P., "Medical Communications," *IEEE Journal on Selected Areas in Communications*, 10(7), pp. 1105-1106, September 1992.

McGee, R., and Tangelos, E., "Delivery of Health Care to the Underserved: Potential Contributions of Telecommunications Technology," *Mayo Clinic Proceedings*, 69: pp. 1131-1136, 1994.

Murphy, R. and Bird, K., "Telediagnosis: A New Community Health Resource: Observations on the Feasibility of Telediagnosis Based on 1000 Patient Transactions," *American Journal of Public Health*, 64: pp. 113-119, June 1974.

NHCP (Naval Hospital Camp Pendleton) Abbreviated System Decision Paper 9568094058, 25 April 1995.

NIST (National Institutes of Standards and Technology), *Putting the Information Infrastructure to Work: Report of the Information Infrastructure Task Force Committee on Applications and Technology*, U.S. Department of Commerce, pp. 41-56, May 3, 1994.

NMIMC (Naval Medical Information Management Center), Secretary of Defense Point Paper: Navy Telemedicine Initiative, 1994.

NMIMC (Naval Medical Information Management Center), "The Navy Telemedicine Initiative", Presentation at the 5th Annual Management Information Systems (MIS) Officers Conference, Fairfax, Virginia, 23 January 1995.

PictureTel Corporation, "Videoconferencing Technology Primer," pp. 1-3, 1993.

Preston, J., *The Telemedicine Handbook*, Telemedical Interactive Consultative Services, Incorporated, Austin, TX, 1993.

Roberts, A., "MACC's Computer Mail System: Its Features, Usage Statistics, and Costs," in *Teleconferencing and Interactive Media*, Parker, L.A. and Olgren, C.H. eds. Madison: University of Wisconsin-Extension, 1980.

Siebert, D., and Sanborn, C., "Comments on the Evaluation of Telemedicine Programs," in *Telemedicine: Explorations in the Use of Telecommunications in Health Care*, Bashshur, R.L., ed. Springfield, IL: Thomas, 1975.

Slawter, B., "On-Ramp to the Super Highway: North Carolina's Proposed Wide-Area Network Makes It a Testing Ground for ATM Technology," *LLAN Computing*, 4(10) pp. 28-29, 1993.

Sprague, R.H. and McNurlin, B.C., *Informations Systems Management in Practice*, Prentice-Hall, 1993.

Stallings, W., *Data and Computer Communications*, Macmillan Publishing Company, 1994.

Tillery, L., *Managing Technological Change in a Military Treatment Facility: A Case Study of Medical Diagnostic Imaging Support (MDIS) System*, Master's Thesis, Naval Postgraduate School, Monterey, California, September, 1994.

Yin, R.K., *Case Study Research: Design and Methods*, Sage Publications, 1988.

BIBLIOGRAPHY

Beck, J.R. et al., "Outreach to Oregon Physicians and Hospitals: 5000 by 2000. *Annals of the New York Academy of Sciences*, 670: 91-97, 1992.

Binkhuysen, F.H.B., "Impact of PACS on Radiologists' Daily Work in Western Countries," *IEEE Journal On Selected Areas in Communications*, 10(7) pp. 1158-1160, September 1992.

Brancheau, J.C., and Johnson, T.J., "Making the Business Case for Migrating to Open Systems Technologies," *Colorado Open Systems Consortium and University of Colorado at Boulder*, pp. 1-30, March, 1994.

Chipman, K., Holzworth, et al., "Medical Applications in a B-ISDN Field Trial," *IEEE Journal On Selected Areas in Communications*, 10(7), pp. 1173-1186, September 1992.

Cox, J.R., Muka, E, Blaine, et al., "Considerations in Moving Electronic Radiography into Routine Use," *IEEE Journal On Selected Areas in Communications*, 10(7), pp. 1108-1119, September 1992.

Cukor, Peter and Baer, Lee, "Human Factors Issues in Telemedicine; A Practical Guide With Particular Attention to Psychiatry," *Telemedicine Today*, 2(3), 1994.

Dwyer, S.J., Templeton, A.W. et al., "Teleradiology Using Switched Dialup Networks," *IEEE Journal On Selected Areas in Communications*, 10(7), pp. 1161-1171, September 1992.

Garner, R., "Medicine Turns to the Mac for Training, Diagnostic Tools," *MacWEEK*, 8(6) pp. 59-61, 1994.

Moore, Gordon , *et al.*, "Comparison of Television and Telephone for Remote Medical Consultation," *New England Journal of Medicine*, 292(14), pp. 729-732, June 1975.

Murphy, R.L.H., Block, P., Bird, K.T., and Yurchak, P. "Accuracy of Cardiac Auscultation by Microwave," *Chest*, 63, pp. 578-581, Jan-Jun 1973,

Murphy, R.L.H., *et al.*, "Accuracy of Dermatologic Diagnosis by Television," *Archives of Dermatology*, 105, pp. 833-835, June 1972.

No Author, "Proposal Outline to United States Navy From Harvard Medical School Telepsychiatry Project," 1994.

Orozco-Barbosa, L., Karmouch, A., et al., "A Multimedia Interhospital Communications System for Medical Consultations," *IEEE Journal On Selected Areas in Communications*, 10(7), pp. 1145-1156, September 1992.

Rinde, E., Nordrum, I., and Nymo, B.J., "Telemedicine in Rural Norway," *World Health Forum*, 14, pp. 71-77, 1993.

Tomich, Nancy, "MDIS: Foundation For Telemedicine Data," *U.S. Medicine*, 30(19), October 1994.

Treves, S.T., Hashem, E.S., et al. "Multimedia Communications in Medical Imaging," *IEEE Journal On Selected Areas in Communications*, 10(7), pp. 1121-1131, September 1992.

Wettson, C.L., and Benschoter, R., "Two-Way Television: Helping the Medical Center Reach Out," *American Journal of Psychiatry*, 129(5), pp. 624-627, November 1992.

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